Deep image reconstruction from the human brain

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Our internal visual world is thought to be encoded in hierarchical representations in the brain. However, previous attempts to visualize perceptual contents based on machine-learning analysis of fMRI patterns have been limited to reconstructions with low level image bases or to the matching to exemplars. While categorical decoding of imagery contents has been demonstrated, the reconstruction of internally generated images has been challenging. I introduce our recent study showing that that visual cortical activity can be decoded (translated) into the hierarchical features of a pre-trained deep neural network (DNN) for the same input image, providing a way to make use of the information from hierarchical visual features. Next I present a novel image reconstruction method, in which the pixel values of an image are optimized to make its DNN features similar to those decoded from human brain activity at multiple layers. We found that our method was able to reliably produce reconstructions that resembled the viewed natural images. While our model was solely trained with natural images, it successfully generalized to artificial shapes, indicating that our model was not simply matching to exemplars. The same analysis applied to mental imagery demonstrated rudimentary reconstructions of the subjective content. Our method can effectively combine hierarchical neural representations to reconstruct perceptual and subjective images, providing a new window into the internal contents of the brain.

Reference:

Horikawa, T, Kamitani, Y (2017) Generic decoding of seen and imagined objects using hierarchical visual features. *Nature Communications* 8, 15037.

Shen, G, Horikawa, T, Majima, K, and Kamitani, Y (2019) Deep image reconstruction from human brain activity. *PLOS Computational Biology* 15, e1006633.

Biography:

Yukiyasu Kamitani received B.A. from The University of Tokyo in 1993, and Ph.D. from California Institute of Technology in 2001. After working at Harvard Medical School and Princeton University, he joined ATR Computational Neuroscience Laboratories in 2004, where he led Department of Neuroinformatics. Since 2015 he is Professor at Kyoto University. He is a pioneer of brain decoding, which combines neuroimaging and machine learning to translate brain signals to mental contents.
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