Abstract of Presentation

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Computational neuroscience, Noninvasive neural activity measurement, Visual system, Sensory perception

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Visual image reconstruction from human brain activity

Abstract :

Decoding of neural activity patterns advances quantitative understanding about how sensory input is represented in the brain. Recent functional magnetic resonance imaging (fMRI) studies have shown that presented visual features, such as orientation, motion direction, and visual object categories can be predicted from fMRI activity patterns by a "decoder," which is trained by statistical machine learning so as to classify the brain activity patterns into one of several pre-specified stimulus categories. However, such a simple classification approach becomes difficult if the number of stimulus categories increases, since decoders need to be trained for all the possible candidate stimuli. Furthermore, the approach predicts a categorical value as a result of classification, but does not reveal a visual image as it is.

We have recently overcome these limitations by "visual image reconstruction" technique, which allows us to translate the brain activity pattern into a visual image directly. We assume that an image is represented by a linear combination of local image bases of multiple scales, whose contrasts are independently predicted from the multi-voxel patterns. As each of the image bases has fewer possible states than the entire image, the training of local decoders requires only a small number of training samples. Hence, each local decoder serves as a "module" for a simple image component, and the combination of the modular decoders allows us to represent numerous variations of complex images.

In this talk, we present the basic methodology of visual image reconstruction and then show that contrast-defined images consisting of 10 x 10 binary patches (2^{100} possible variations) can be reconstructed with high accuracy. Further analyses show that the primary visual cortex carries more information in correlated activity patterns than other areas for reconstructing visual images. The image bases were also estimated from given fMRI activity patterns. Thus our approach provides a powerful technique to read out human perceptual contents, and also serves as a novel means to elucidate information representation in the human brain.