Understanding Representation and Computation in Visual Cortex with Hierarchical Learning Models

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How does our visual system attain the remarkable capability to recognize and understand our surrounding visual scenes? Although traditional visual neuroscience has attempted to answer this question by accumulating experimental facts in visual cortex, it is important to theoretically understand the underlying computational principle of how incoming visual information is encoded and manipulated. The seminal study by Olshausen and Field [1] has shed light into this by explaining receptive field characteristics in V1 remarkably well using a sparse coding model of natural images. In this talk, I present our recent series of work to extend this approach to understand visual areas beyond V1 using multi-layered models that learn certain kinds of naturalistic image data. Specifically, in the first part, I show a hierarchical sparse coding model that can qualitatively and quantitatively reproduce three relatively complex properties of local orientation organization that has been found in past experiments of macaque V2 [2]. In the second part, I explain a hierarchical mixture of sparse coding models that can explain selectivity and certain tuning properties of face neurons in the higher visual cortex in relation to parts-based and holistic processing [3]. Finally, I touch on our on-going project of an integrative hierarchical learning model of visual cortex, emphasizing the importance of feedback processing in learning and inference for complex visual computation.

References

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[3] Hosoya H, Hyvärinen A. A mixture of sparse coding models explaining properties of face neurons related to holistic and parts-based processing. bioRxiv, 2016. doi: http://dx.doi.org/10.1101/086637.