NEUROSCIENCE 2019

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Efficient visual neural coding tutorial for grayscale, color, binocular, and video to produce v1 neural receptive fields

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Abstract:
Early visual processing is known to efficient encode our natural world. By efficiently encoding natural visual scenes (e.g. rocks, trees, prairie, etc) the derived code resembles the encoding strategy of simple cells in primary visual cortex (V1). This has been used used to succinctly explain neural response properties in a variety of visual modalities including black/white, color, binocular, and video (and any arbitrary combination of those). The same efficient coding algorithm can be applied, with only a change in input data. That flexibility is the power of a computational level of understanding sensory systems. We created a self-contained Jupyter notebook using Python that demonstrates the efficient coding principle in a systematic way for the different visual modalities. For each modality, we contrast resulting filters from both natural and non-natural images demonstrating how V1 neural codes are not produced when the images sufficiently deviate from those animals were evolved to process. Similarly, we contrast an efficiency metric which matches constraints and goals of neural processing, such as Independent Components Analysis (ICA), to efficiency metrics that are more popular in general practice, but are not appropriate for most neural coding, such as Principal Components Analysis (PCA). The tutorial works by using pre-selected images and videos and proceeding through the following steps for each visual modality. 1) read in the images or video 2) extract small patches 3) apply an encoding strategy (ICA or PCA), and 4) display a visual tiling of the resulting receptive fields to compare to provided experimentally measured receptive fields. This is done in turn for each visual modality reusing code to emphasize that each modality can be modeled with only a change in inputs.Using this notebook, students without any prior programming experience will be able to follow the steps to generate receptive field models from an efficient coding of natural images in a wide variety of visual modalities including grayscale, color, binocular, and video. Most importantly, this work demonstrates the power of computational principles like efficient coding to a

broader audience of neuroscientists.
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