Comparing diverse V1 models on the same platform: Virtual V1sion

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Virtual V1sion was conceived in 2016 as an open-source platform on which a diverse user community could collaborate to develop a better model of V1 than exists in any one laboratory. When a Gabor-based model was used as an example during presentation of the Virtual V1sion concept at MODVIS 2016, there was broad concern that developing the framework while relying on the convenience of Gabor models would create unnecessary and potentially damaging constraints for future efforts. In response, I refactored the code base to ensure that nothing in the structure commits to a particular receptive field structure. Not surprisingly, this was a useful exercise that resulted in dramatic improvements to the robustness and flexibility of the tools. This year, I will present this improved model, the supporting git repository, and the basic procedures for mixing code and data components between laboratories.

As a proof of principle, I will present the results of using three different receptive field structures, mixed and matched with different local normalization (gain control) rules, to produce V1 output simulations that can be compared against both canonical and contributed datasets. The receptive field structures tested as a proof of principle are: Gabor elements, an overcomplete wavelet basis set learned from natural images, and simulated Layer 4 units with receptive fields created by explicit spatial summation of LGN-like receptive fields.

At this point, it does not matter which of the presented models is the “winner”. On-going interests in my laboratory aim to use this framework to test (1) whether flexible normalization (Coen-Cagli *et al,* 2015) can be used to improve encoding models for fMRI data (Naselaris *et al*, 2009, 2015), and (2) the degree to which the normalization model of attention (Reynolds and Heeger, 2009) can be modeled as a type of flexible normalization. Therefore, the components of Virtual V1sion that support these efforts are currently receiving more attention and are better developed, i.e., do a better job of fitting the datasets currently available on Virtual V1sion.

What is of most interest to a broad audience is the generalizability of these results (can my current favorite model state explain your dataset?) and the ease with which the object-oriented nature of the code base allows a person to swap in and out different components to compare results. We are looking for beta-testers to partner with us in (1) testing methods for contributing new model elements and (2) determining what are the most instructive, publically available datasets that should be used for judging modeling success. For model elements, a non-exhaustive list of components that can readily be interchanged, edited or replaced by new users is: receptive field structure, initial stimulus-response rules (e.g., contrast non-linearities that occur before V1), the mapping between visual space and cortical space that supports spatial summation for creating tuned and/or untuned normalization pools, and the structure of any population-level normalization that the user might want to apply after initial responses are computed. As internal architecture of each section of code changes, public attributes stay the same so improvements can be tested against the same inputs and outputs and linked to the same visualization tools. We are eager for new contributors to use this framework to demonstrate how their models and/or datasets can improve Virtual V1sion.