Model Parameter Selection for Bock et al. V1 Orientation-tuned Connectivity Model

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Overview

In their 2011Nature Paper, Bock et al used a combination of *in vivo* physiology and electron microscopy (EM) to connect the literatures regarding the functional orientation tuning among V1 neurons and their anatomical connectivity patterns. The authors found evidence among a 14 neuron network for convergent orientation information impinging on down-stream inhibitory neurons. This novel result shed light on how visual information is propagated through V1 at the micro-circuit level and offered clues as to the computational mechanisms behind the impressive visual transformations V1 achieves on the (relatively) raw information it receives from the retina.

However from a graph theoretic perspective it remains unclear how the V1 orientation ought to be interpreted. Analyzing a graph is highly dependent on the model used and the parameters ascribed to that model; the authors of (Bock et al., 2011) did not have this as a primary focus and so here one plausible scheme for setting some key models parameter is discussed.

Model Parameters

Let *G = (V,X,Y,L)* where *G* is a graph defined by a set of nodes, *V*, a set of edges, *X,* a set labels for excitatory/inhibitory, *Y*, and labels for preferred orientation, *L.* Then $z \in L$ refers to the discretized set of preferred orientations from 0° to 180° (noting that only one half-circle is needed to define all orientations because a static, orientated edge has no direction). It is proposed here that the number of elements in *z* should be such that the orientation resolution is 1°, i.e. $z \in$(0:1:180). The rationale for this is that the higher the resolution the better, but with the admittedly arbitrary caveat that decimal-level resolution may be superfluous. The next parameter to set is ρ(z) which defines the probability of a neuron having a given preferred orientation. In other words ρ: $L \rightarrow \Delta_k$ where k is the number of elements in **ρ.** Behavioral and functional evidence shows that not all orientations are equally likely; there is a bias against oblique orientations and in favor of horizontal or vertical ones. Subjects asked to determine the tilt of a hanging picture were four-fold worse at oblique angles than straight ones (Mach,1861). This effect was later termed the oblique effect (Appelle, 1971). Functional MRI (fMRI) data corroborates this, noting a disproportionate amount of activity representing 90° orientations and a relative dearth for 45° (Yacoub et al., 2008). Therefore it is proposed here to use a mixture of two Gaussians to represent relative probabilities such that the peaks are at 0° and 90° and the total integral is 1 (i.e. all probabilities sum to 1, as required by the ρ simplex). The distribution of the 181 blocks (180 degrees and 1 inhibitory block with no preference) in the β parameter which determines the block connectivity will be a function of z which in turn is a function of ρ which in turn is a mixed Gaussian distribution reflecting empirical evidence of orientation weight.

References

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