

# A method to estimate statistical properties of input currents and network structure from dynamics of rate and spike irregularity

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Accumulating evidence from intracellular recordings during the UP state, and computational modeling studies indicate that cortical cells are driven by approximately balanced inputs [1, 2, 3, 4]. Such balanced inputs must be generated at least in part from local interconnected networks of excitatory and inhibitory cells. However, it is still unclear how the dynamics of input currents to a cell is related to the architecture of the local cortical circuit in which the cell takes part.

Here, we propose a new method to obtain information about the local network from extracellular electrophysiological recordings. The method relies on the non-stationarity of instantaneous firing rate and an instantaneous measure of spike train irregularity, such as the  $CV_2$  metric [5]. It is composed of three steps:

(i) given a particular single neuron model, one can estimate the dynamics of input current for a measured spike train by using the inverse map from instantaneous firing rate  $\nu$  and  $CV_2$  to the mean  $\mu$  and standard deviation  $\sigma$  of the input.

(ii) given a particular network architecture, one can estimate the possible trajectories in the  $\mu$ - $\sigma$  plane, when the external inputs to the network are varied. These trajectories depend strongly on network parameters, such as the ones that control the balance between excitation and inhibition.

(iii) one can infer parameters of the local network of a cell by minimizing the distance between the model trajectory in the  $\mu$ - $\sigma$  plane (using step ii) and the one obtained from the electrophysiological measurements (using step i).

We have applied this strategy to extra-cellular recordings in the motor cortex of behaving Rhesus monkey during a delay response task [6]. Our analysis (step i) suggests that the estimated input currents from cells with high spike irregularity (high  $CV_2$ ) are driven by sub-threshold input, even when the firing rates are elevated. Furthermore, it suggests that most irregularly spiking neurons are embedded in an inhibition-dominated network (steps ii-iii). On the opposite, those with regular spike patterns seem to be part of an excitation-dominated network. This paper provides a simple method to estimate both input statistics of a cell and parameters of its local network, which could be helpful to further our understanding of local cortical circuits.

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