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Optimizing artificial neurons to be successful Reichardt detectors

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Neurons come in a wide variety of shapes and a wide variety of characteristics that is made up by the distribution of active conductances; the combination of neuronal shape and characteristic is referred to as the morphology. It is known that the wide variety of neuronal morphologies parallel the diversity of neuronal computational functions. This so-called neuronal morphology-*function* relationship has received major attention lately. However, a problem with most neurons is that the exact *function* is unknown. We previously developed a method that directly relates morphology with function by optimizing neuro-anatomical models that can perform a predefined function [1]. Using this method, we established a systematic mapping of isolated characteristics of function onto morphology [2].

In this work, we use our methodology to investigate the neural morphology (i.e., shape and distributions of conductances) necessary for an Elementary Motion Detector (EMD) or Reichardt detector. In an abstract form, an EMD consist of two inputs that are connected with a summation device; one of the inputs is delayed. Then, motion is detected when two inputs arrive simultaneously at the summing device. In reality, the inputs come from afferents that connect to single neurons but on different dendritic sites. Due to the band-pass filtering properties of dendrites the input can be delayed, and coincidence detection indicates motion.

We performed different optimizations of neuro-anatomical models for the motion detection task in which input spike trains are injected into synapses at 6 distinct locations. We investigated how morphology adapts to three variations of the task; (i) straightforward motion detection, (ii) detection of directed motion, (iii) detection of motion at different velocities. Results were validated by comparing them with existing morphological and physiological data of fly lobular plate tangential cells.

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