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Comparison of match functions applied to records with trains of action potentials

Jose Ambros-Ingerson*[1], Lawrence M Grover[2] and William R Holmes[1]

Address: [1]Dept of Biological Sciences, Ohio University, Athens, OH 45701, USA and [2]Dept of Pharmacology, Physiology and Toxicology, Marshall University School of Medicine, Huntington, WV 25755, USA

Email: Jose Ambros-Ingerson* - ambros@alumni.uci.edu

* Corresponding author

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Any attempt to construct a realistic computational model of a neuron has to face the difficult problem of assigning values to a large number of parameters. The parameter value ranges obtained experimentally are often insufficient to constrain the behavior of a model; parameter values are frequently encountered that are within experimental estimates but result in vastly dissimilar outputs.

Finding parameter values to make the model match complete experimental waveforms may address the failure of direct parameter estimates to sufficiently constrain parameter values. Automated optimization techniques can be used with this approach provided appropriate target match functions are available. However, a sum of squared differences comparison between traces with trains of action potentials suffers from their narrow shape and subtle variation in peak times.

To address this issue we developed a novel match function that uses the time-points of action potentials as fiducial points. We tested its performance using a set of patch-clamp 500 ms depolarizing (+800 pA) current pulse recordings from hippocampal CA1 pyramidal cells, using a criteria based on the notion that traces from the same cell should be closer to each other than to those from other cells.

We found that fiducial-point matching realized our criteria and also outperformed other published methods, such as those based on spike times and on voltage-gradient phase planes. Thus, based on fiducial-point scores, CA1 pyramidal cell responses from one cell can be systematically differentiated from those of other cells.

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