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A qualitative optimization technique for biophysical neuron models with many parameters

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We present a novel computational technique that enables more efficient optimization of qualitative features in biophysical neural models. We extend the idea of multiple objective optimization for a single comparison modality (such as comparison of individual voltage traces) [1] into multiple modalities. For instance, features may be defined in terms of measurements from different experimental scenarios, and might include not only action potential spike shape characteristics (Cf. [1,2]) but also complex features such as the frequency response curve, and phase response curve (PRC). Multiple fuzzy feature modalities provide additional ways to distinguish solutions that might otherwise appear similarly fit in the restrictive view of a single modality and with crisp measures of fitness. An ill-posed optimization problem with many local minima typically arises from relative insensitivities of some parameters to features in a single modality, or parameter co-variation/modulation [2].

We use an implementation in the PyDSTool software [3] to demonstrate how the multi-modal approach can be prepared and embedded in conventional gradient-based or global optimization algorithms. Among other applications, we discuss the transformation over 25 model parameters of a Hodgkin-Huxley neuron model with a Type I PRC [4] to a Type II PRC, using a goal PRC shape and other periodic trajectory statistics as fuzzy objective modalities.

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