In this thesis, a weighted least squares approach is initially presented to estimate the parameters of an adaptive quadratic neuronal model. By casting the discontinuities in the state variables at the spiking instants as an impulse train driving the system dynamics, the neuronal output is represented as a linearly parameterized model that depends on filtered versions of the input current and the output voltage at the cell membrane. A prediction error-based weighted least squares method is formulated for the model. This method allows for rapid estimation of model parameters under a persistently exciting input current injection. Simulation results show the feasibility of this approach to predict multiple neuronal firing patterns. Results of the method using data from a detailed ion-channel based model showed issues that served as the basis for the more robust resonate-and-fire model presented.

A second method is proposed to overcome some of the issues found in the adaptive quadratic model presented. The original quadratic model is replaced by a linear resonate-and-fire model -with stochastic threshold- that is both computationally efficient and suitable for large network simulations. The parameter estimation method presented here consists of different stages where the set of parameters is divided into two. The first set of parameters is assumed to represent the subthreshold dynamics of the model, and it is estimated using a nonlinear least squares algorithm, while the second set is associated with the threshold and reset parameters as its estimated using maximum likelihood formulations. The validity of the estimation method is then tested using detailed Hodgkin-Huxley model data as well as experimental voltage recordings from rat motoneurons.

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The public is welcome to attend.