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Spike-Sorting by Spectral Analysis of Single Action Potentials: Outline

1. Introduction
    1.1. Membrane potential information content
    1.2. Spike-sorting methods
    1.3. Action potential information content
    1.4. Information in an action potential as a method in spike-sorting

2. Methods
    2.1. Theory (Details in appendix)
    2.2. Computational Tools
    2.3. Experimental Design (Procedure; data flow diagrams)
        2.3.1. Intracellular single-neuron analysis
            2.3.1.1. Simulation of membrane potential
                2.3.1.1.1. Simulation of ion channels undergoing Markov kinetics
                2.3.1.1.2. Transformation to spike-trains
            2.3.1.2. Extraction of action potentials from spike-trains
                2.3.1.2.1. Action potential averaging
            2.3.1.3. Spectral analysis of averaged action potentials
                2.3.1.3.1. Spectral characteristics as a function of injected current density
                2.3.1.3.2. Spectral characteristics as a function of ion conductance density
                    2.3.1.3.2.1. Sodium channels
                    2.3.1.3.2.2. Potassium channels
            2.3.1.4. Comparative analysis
                2.3.1.4.1. Action potential shape analysis
                2.3.1.4.2. Spike-train analysis
            2.3.1.5. Effect of computation parameters (sampling rate, white noise, and action potential window)
        2.3.2. Extracellular multi-neuron spike-sorting
            2.3.2.1. Simulation of extracellular field potential
            2.3.2.2. Extraction of action potentials from spike-trains
            2.3.2.3. Spectral analysis of action potentials

3. Results
    3.1. Method development - Intracellular single-neuron action potential
        3.1.1. Spectrogram of single action potentials
            3.1.1.1. Effect of injected current density
                3.1.1.1.1. Effect on spectral characteristics
                3.1.1.1.2. Shape analysis
                3.1.1.1.3. Firing rate
                3.1.1.1.4. Summary
            3.1.1.2. Effect of sodium channel density
                3.1.1.2.1. Effect on spectral characteristics
                3.1.1.2.2. Shape analysis

3.1.1.2.3. Firing rate
3.1.1.2.4. Summary
3.1.1.3. Effect of potassium channel density
3.1.1.3.1. Effect on spectral characteristics
3.1.1.3.2. Shape analysis
3.1.1.3.3. Firing rate
3.1.1.3.4. Summary
3.1.1.4. Summary
3.2. Implementation of spectral spike-sorting
3.2.1. Simulated field potential
3.2.2. Empirical field potential
3.3. Summary

4. Discussion
4.1. Assumptions
4.2. Validity of spike-sorting by spectral analysis of action potentials
4.3. Recommendations for future studies

Appendices

A. The stochastic Hodgkin-Huxley model
B. Extracellular field potential
C. Spectral Analysis
D. Effect of computational parameters
D.1. Sampling rate
D.2. White noise
D.3. Action potential window width and offset
E. Results (in detail)
F. Source Code