A Model of Auditory Spiral Ganglion Neurons for Acoustic and Electrical Excitation

Abstract:
For both normal hearing subjects and cochlear implant patients the most drastic step of sound coding for neuronal processing is when the analog signal is converted into discrete nerve-action potentials. As any information lost during this process is no longer available for neural processing, it is important to understand the underlying principles of sound coding in the intact auditory system and the limitations in the case of direct electrical stimulation of the auditory nerve. Here we focus on a model of spiral ganglion type I neurons with Hodgkin-Huxley type ion channels, which are also found in cochlear nucleus neurons (KA, Kht, Klt). Depending on the task, we model the neurons at different levels of detail. For acoustic stimulation, we model the postsynaptic bouton (1.5 x 1.7 µm) from high-spontaneous rate fibers and a synaptic excitation model fitted to results from Glowatzki and Fuchs (2002). To study the response to electrical stimulation in detail, we use a multi-compartment model and an approximation of the electrical field along the neuron. For automatic speech recognition and information theoretic calculations we use simplified single compartment versions. We analyze the quality of coding with the framework of automatic speech recognition and the methods of information theory. Our results show that for acoustic stimuli, the model provides realistic refractoriness and generates more realistic spike trains compared to an artificial spike generator. Not surprisingly, speech discrimination in electrical hearing is lower than in acoustic hearing. This is probably due to the limited dynamic range of electric hearing and the wide current spread, which limits spectral resolution. On the other hand, the temporal precision of information coding...
seems to be very high because at levels well above threshold, action potentials are elicited quasi deterministic by the electrical stimuli. We argue that CIS strategies a) waste as much as 50

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