E.N. Spanou
Democritus University of Thrace, Xanthi, Greece
e-mail: ispanou@ee.duth.gr
A.G. Rigas
Democritus University of Thrace, Xanthi, Greece
e-mail: rigas@ee.duth.gr
V.G. Vassiliadis
Democritus University of Thrace, Xanthi, Greece
e-mail: bvasil@ee.duth.gr

The identification of a neuroelectric system in the time and frequency domain when an alpha stimulation is present

In this work the identification of a neuroelectric system, called muscle spindle, is studied when it is affected by an alpha motoneuron (alpha stimulation). The muscle spindle is an element of the neuromuscular system and plays an important role in the initiation of movement and in the maintenance of the posture. The response of the muscle spindle and the stimulus imposed by the motoneuron are sequences of action potentials and therefore they are considered as realizations of stationary point processes. A frequency and a time domain approach has been employed for the identification of the system.

In the frequency domain, the muscle spindle can be described by a Volterra - type model involving one input and one output. Spectral analysis techniques of stationary point processes are applied in order to estimate two important functions, the coherence coefficient and the impulse response. The linear relation between the response of the system and the input is described by the estimate of the coherence coefficient, while the estimate of the impulse response function provides the best linear predictor for the response of the system in the presence of the input.

In the time domain approach the input and the output of the system can also be considered as binary time series and therefore the theory of generalized linear models (GLM) can be applied. The advantage of this approach is based on the fact that estimates of the system's parameters can be obtained by using the maximum likelihood function. However, there is no convergence of the maximum likelihood estimates since the phenomenon of quasi-complete separation occurs. To overcome this problem an approach based on the penalized likelihood function is used, which provides an ideal solution and it is computationally much faster compared to the Monte Carlo method that has been already used. The stochastic model which is proposed for the description of the system involves the threshold and the summation function. The estimation of the summation function is of great interest as it describes whether the system is excitatory or inhibitory. A validity test for the fitted model based on randomized quantile residuals is proposed. The validity test is transformed to a goodness of fit test and the use of Q-Q plot is also discussed.

The estimate of the impulse response function indicates that the system accelerates for 1–2 ms shortly after the effect of the alpha motoneuron, is blocked for about 30 ms and after that does not change. Similar results are obtained by the estimate of the summation function of the GLM.

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