Adaptive stimulus design for dynamic recurrent neural network models.

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Özet:

ABSTRACT:

We present a theoretical application of an optimal experiment design (OED) methodology to the development of mathematical models to describe the stimulus-response relationship of sensory neurons. Although there are a few related studies in the computational neuroscience literature on this topic, most of them are either involving non-linear static maps or simple linear filters cascaded to a static non-linearity. Although the linear filters might be appropriate to demonstrate some aspects of neural processes, the high level of non-linearity in the nature of the stimulus-response data may render them inadequate. In addition, modelling by a static non-linear input - output map may mask important dynamical (time-dependent) features in the response data. Due to all those facts a non-linear continuous time dynamic recurrent neural network that models the excitatory and inhibitory membrane potential dynamics is preferred. The main goal of this research is to estimate the parametric details of this model from the available stimulus-response data. In order to design an efficient estimator an optimal experiment design scheme is proposed which computes a pre-shaped stimulus to maximize a certain measure of Fisher Information Matrix. This measure depends on the estimated values of the parameters in the current step and the optimal stimuli are used in a maximum likelihood estimation procedure to find an estimate of the network parameters. This process works as a loop until a reasonable convergence occurs. The response data is discontinuous as it is composed of the neural spiking instants which is assumed to obey the Poisson statistical distribution. Thus the likelihood functions depend on the Poisson statistics. The model considered in this research has universal approximation capability and thus can be used in the modelling of any non-linear processes. In order to validate the approach and evaluate its performance, a comparison with another approach on estimation based on randomly generated stimuli is also presented.

ÖZGEÇMİŞ:

VITA:

Dr. Doruk is a graduate of Department of Mechanical Engineering at Middle East Technical University. Following the graduation in the year 2000, he moved to the Department of Electrical and Electronics Engineering to pursue a Master of Science (M.Sc.) study and it is completed in year 2003.
He received his Ph.D. degree from the same department in 2008. His graduate studies are concentrated on control theory applications in defence research areas;mainly the control of missile manoeuvres and satellite attitude motion. Between the years 2008 - 2012 he worked as a lecturer in the Northern Cyprus Campus of Technical University and taught courses on electrical and electronic circuits laboratories.
In this time course, his interests shifted to theoretical neuroscience and he moved to USA in the year 2012 and joined the theoretical neuroscience laboratory headed by Dr. Kechen Zhang at the Johns Hopkins Medical School .
During this stay, the group mainly engaged with the development of a mathematical model for the excitatory and inhibitory sensory neuron populations in the auditory cortex.