論文の内容の要旨

論文題目　Theory and Application in Point Process Analysis of Neural Spike Trains
（神経スパイク時系列の点過程解析における理論と応用）

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（本文）Generally, it is assumed that the information coding is done by the spike signal which is the neuronal responses. However, neuron in the cerebral cortex, which is said that a more higher-order function is governed, emits spikes very irregularly with low reproducibility. The question of why the brain works elaborately though such a seemingly probabilistic vague neurons has been studied for a long time, to search for the meaning of the spike signals.

Statistical analysis of a single neuron is an important issue, since we still don't know sufficiently about the information coding or processing system even in a single neuron level. Chapter 2 and 3 focus on a single neuron statistical analysis.

In chapter 2, we examine the conventional simple spiking neuron model, leaky integrate-and-fire (LIF) with several inputs and show that it does not fully account for the behaviors of the ISI statistics obtained from the bursting sequence of the gustatory cortex. We pursuit the reason of nonreproducibility by the LIF model and propose the simple neuron model to reproduce their behaviors. Then, we consider the interpretation of our proposed neuron model. We compare our model with other more complicated neuron models, and find that they have a commonality. Further comparisons with the real experimental data have been done, and discuss the underlying neuronal mechanism of bursting behavior in the rat gustatory cortex.

In chapter3, we classify the spike sequences by distinguishing their sources of temporal correlations. Spike sequences generally differ from an entirely random sequence, and exhibit temporal correlations. We confine three sources of temporal correlations, and propose an algorithm that distinguishes the sources of the temporal correlations of spike sequences. Statistical characteristics of the spike sequences play a key role in this algorithm. This algorithm helps to classify the spike sequences by discriminating their sources of temporal correlations.

Recently, the research of multi-neuron that is based on the recording of the activity of two or more neurons, has been a hot topic in neuroscience. However, how we treat a huge amount of neuronal spikes to solve the information coding problem at the network level has not been done sufficiently. Another way of saying, method of statistical analysis on multi-neuron data is demanded but not yet established. Therefore, we propose a new concept of analyzing the experimental data in chapter 4 and 5.

In chapter 4, we introduce a concept of ergodicity of the spike trains, which is the equivalence between the trial firing rate and the population firing rate. We propose some higher order statistical measures between trials and between neurons, and investigate how characteristics of noisy neural network models, such as single neuron properties of LIF model, external stimuli, and synaptic inputs, affects our proposed measure. The results show that those measures may detect the population synchrony, and the same holds for the trial synchrony. We also apply this concept to real experimental data, and estimate the neuronal property in the data.

In chapter 5, we propose an analytic method to measure the modulation of distribution and patterns of ISIs. We overcome statistical difficulties by using rate-independent statistics and multiple trials. Finally, we apply our method for measuring time-varying statistics for physiological data. It may be possible to obtain interesting information by this analytic method.

All the studies in this paper involve analyses of real physiological experiments. We think that theoretical studies in theoretical neuroscience must share their profits for experimental studies. It is a future problem to sophisticate our study and contribute for the further cooperation with the experimentalists.