(様式 5)

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学位（博士）論文要旨

(Doctoral thesis abstract)

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論 文 題 目 (Title)	An EEG modeling methodology based on the collective almost synchronization phenomenon

論文要旨（2000 字程度）
(Abstract(400 words))
※欧文・和文どちらでもよい。但し、和文の場合は英訳を付すこと。
(in English or in Japanese)

Electroencephalography (EEG) is one of the essential non-invasive brain imaging methods for studying the human cognitive function and diagnosing brain diseases. A better understanding of how different types of brain activity are reflected in the cortical current dipole creates a better inverse model for sound source localization and the mechanism of human cortical activity. It may lead to a better understanding of brain diseases and the cure of diseases.
The EEG can measure the macroscopic collective activity of the brain with higher time resolution and is widely used to understand the electrophysiology of brain activity that correlates with cognitive function and motor regulation. Since EEG signals are complex and have stochastic, non-linear, and non-stationary characteristics, it is out of the question to apply classical time series analysis techniques. In this thesis, we have investigated that the EEG signal can be modeled as the sum of the action potentials of the oscillators that model the action potentials of living neurons. Hence, a neuron model-based approach is used to understand the dynamic nature of EEG signals better. EEG is a useful biological signal to distinguish different brain diseases and mental states. It is an technique for recording human brain signals, and is crucial for the Brain-Computer interface (BCI).

Firstly, we propose a model based on a complex network of weakly connected dynamical systems (Hindmarsh-Rose (HR) neurons or Kuramoto oscillators) configured to operate in the dynamic domain. This thesis shows that the best way to reconstruct an EEG signal from a complex oscillator network is to construct an output function (weighted average signal of action potentials of multiple neurons). Using this method, we show that the time-series orthogonal sets produced by the complex network of both HR and Kuramoto oscillators minimize the error function that fits the EEG data. The proposed model successfully reproduces EEG signal data in both healthy and epileptic patients and can also predict EEG characteristics such as the Hurst index and power spectrum.

Secondly, as a consequence of the modeling approach, a novel EEG feature extraction method which can improve the Motor Imagery (MI) classification introduced. Purpose of this study is to investigate the performanceof the CAS model to identify features in the classification of MI states. To achieve this goal, a linear regression method is used and linear coefficients are extracted as feature vectors. Our approach boils down to identifying patterns in the MI-EEG by associating them to the coefficients of a linear regression constructed to model the MI-EEG signal by signals generated by our dynamical network. MI-EEG dataset 2b from BCI Competition-IV was used to evaluate the performance of the proposed method.

The result of MI classification indicated that the proposed feature method is more robust in extracting distinguishable features from EEG signals as compared with Fast Fourier transform ($p < 0.05$). Moreover, the MI classification for across subjects was improved.

（英訳）※和文要旨の場合(400 words)