別紙様式３

学位論文の要旨

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【論文の要旨】（和文の場合1,200字程度、英文の場合800語程度）

Sleep disorder is a medical disease of the sleep patterns, which is commonly suffered by the elderly. Sleep disorders diagnosis and treatment are considered to be challenging due to a time-consuming and inconvenient process for the patient. It is caused a Polysomnography (PSG) which is the gold standard to assess sleep condition involves a lot of multichannel signals, such as Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG), Electrocardiogram (ECG), respiratory effort signal, and pulse blood oxygen saturation. These multichannel signals will be recorded when patients fall asleep in a specialized laboratory or hospital. Moreover, the use of PSG in sleep disorder diagnosis is a high-cost process, so they refused the observation.

A clinical study widely used the spectrum analysis of Heart Rate Variability (HRV) to assess the personal condition, such as sleep, fatigue, stress, and sudden cardiac death in the last decade. HRV is measured from the variation of heartbeat or known as a cardiac rhythm that can be captured over a certain period of time from the electrocardiography (ECG) signal. HRV also indexes neurocardiac function and is generated by heart-brain interactions and dynamic non-linear Autonomic Nervous System (ANS) processes. The various HRV parameters can show significant differences in each sleep stage, which is associated with ANS activity. Hence, the variation of HRV according to the sleep stage, thereby reflecting the activity of ANS. It is implied that it is also possible to detect a sleep disorder using an ECG signal instead of complicated signal recordings. Therefore, this doctoral dissertation proposes an efficient classification method of sleep disorder by merely using an ECG signal to simplify the sleep disorders diagnosis process. Different from many current related studies that applied a five-minute epoch to observe the main frequency band of the ECG signal, we perform a pre-processing technique that suitable for the 30-seconds epoch of the ECG signal. By this simplification, the proposed method has a low computational cost so that suitable to be implemented in a portable hardware device. Structurally, the proposed method consists of five stages: (1) pre-processing, (2) spectral features extraction, (3) sleep stage detection using the Decision-Tree-Based Support Vector Machine (DTB-SVM), (4) assessment of sleep quality features, and (5) sleep disorders classification using an ensemble of bagged tree classifiers.

This doctoral dissertation is organized as follows. Chapter 1 provides a research background, aims, scopes, contributions, and findings. The definitions of sleep are discussed in Chapter 2. This chapter also describes the sleep disorders in the elderly, sleep scoring standard and the sleep assessment. Chapter 3 describes the sleep database and the proposed methods. As mentioned above, the proposed method is consisting of five stages. Subsequently, to reach the aims of this doctoral dissertation, the proposed method can be divided into three parts: (1) pre-processing, (2) automatic sleep stage detection, (3) automatic sleep disorders classification. The pre-processing part, which includes a new processing technique suitable for the 30-second epoch of ECG signals during sleep is presented in Chapter 4. The automatic sleep stage detection part, which includes spectral features extraction and sleep stage detection stage provided in Chapter 5. Chapter 6 presents the automatic sleep disorders classification part, which includes the assessment of sleep quality features and sleep disorders classification stage. We summarize the conclusion and describe the future work of this doctoral dissertation in Chapter 7.

The selected pre-processing techniques are used to decompose the 30-second of ECG signal in the pre-processing part. Then, two features are obtained from spectral features extraction i.e., normalized Low Frequency and normalized High Frequency. These features were then used as inputs for sleep stage detection. Furthermore, most commonly used learning classifiers are implemented to detect the sleep stage, namely KNN, NN, DT, SVM, and proposed DTB-SVM in the automatic detection part. The proposed method using DTB-SVM based on spectral features of ECG signal achieved a good performance to obtain all sleep stage conditions.

In the automatic sleep disorders classification part, we evaluate the effectiveness of the proposed method in the task of classifying the sleep disorders into four classes (insomnia, Sleep-Disordered Breathing (SDB), REM Behavior Disorder (RBD), and healthy subjects) from the 51 patients of the Cyclic Alternating Pattern (CAP) sleep data. Based on experimental results, the proposed method presents 84.01% of sensitivity, 94.17% of specificity, 86.27% of overall accuracy, and 0.70 of Cohen's kappa. This result indicates that the proposed method able to reliably classify the sleep disorders merely using the 30-seconds epoch ECG in order to address the issue of a multichannel signal such as the PSG.

(注１)　論文博士の場合は、「専攻、入学年度」の欄には審査を受ける専攻のみを記入し、入学年度の記入は不要とする。
(注２)　フォントは和文の場合、10.5ポイントの明朝系、英文の場合12ポイントのtimes系とする。
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