

中文摘要

本研究嘗試以睡眠中的心電圖(electrocardiogram, ECG)資料為基礎，藉由分析睡眠時期由自律神經平衡的變化對心臟跳動頻率的影響，利用心率變異率(Heart Rate Variability, HRV)於時域部份(5 項)以及頻域部份(8 項)的各項特徵值，透過倒傳遞類神經網路進行包含(1)甦醒、(2) REM、(3)NREM stage1、(4)NREM stage2、(5)熟睡(NREM stage3 與 NREM stage4)5 項睡眠階段的辨別。期望藉由不同睡眠階段的分析辨別，進而建立(1)總睡眠時間、(2)睡眠潛伏期、(3)睡眠效率、(4)夜裡覺醒次數、(5)快速眼動期與熟睡階段持續時間等 5 項睡眠品質評估指標。

本研究一共規劃了 3 個實驗：(1)利用統計的方式驗證本研究所選用的特徵值參數是否具備辨別不同睡眠階段的能力。透過 one-way ANOVA 檢定證實各項特徵值參數於各睡眠階段皆達到顯著差異 ($p < 0.001$)。(2)比較不同網路架構與訓練參數設定的睡眠階段辨別網路其對於各睡眠階段之 Youden index，決定較合適的網路訓練參數設定。經實驗測試結果顯示，相對較佳的隱藏層神經元數目設定為 30；性能目標(Sum Squared Error, SSE)設定為 20。(3)透過特徵參數選取方法篩選出較具睡眠階段辨別能力的輸入參數，減少網路輸入維度以降低網路複雜度。輸入參數維度最終從 13 維逐步刪減至 8 維，各睡眠階

段的辨別正確率：甦醒階段可達 62.83%；REM 階段可達 59.43%；
Stage1 階段可達 93.33%；Stage2 階段可達 77.79%；熟睡階段可達
81.75%；網路訓練時間為 1350.7 秒，保留下來的時域特徵值參數為：
SDNN、RMSSD、SDSD、NN50、pNN50；頻域特徵值參數為：HF norm、
VLF%、5mins total power。

英文摘要

Sleep is traditionally divided into five repeating stages: consciousness, rapid eye movement (REM) sleep, non-rapid eye movement (NREM) sleep stage N1, NREM stage N2, and deep sleep (NREM stage N3 and NREM stage N4). In this study, We established a sleep-stage identification model based on the autonomic heart rate variability data (HRV) acquired by electrocardiogram (ECG). Five different features in HRV duration time and eight features in its frequency were recorded during each stage of sleep and analyzed by the backpropagation artificial neural network to establish a quantitative sleep-quality evaluation standard. It is composed of 1) sleep duration, 2) sleep latency, 3) sleep efficiency, 4) arousal times during sleep, 5) duration of REM and deep sleep.

The model was developed through the following logic: 1) evaluating the effectiveness of selected features in distinguishing stages of sleep by one way analysis of variance (ANOVA) test (statistic significance was set to $p < 0.001$). 2) Fine adjustment of the parameters including learning rate, mean squared error and so on. 3) Diminishing the dimension of the neural network. The results showed that the best architecture of neural network has 8 input nodes and 30 nodes in hidden layers. The sum squared error is set as 20. The distinguishing accuracy of deep sleep is 81.75%. The accuracy of NREM stage1, stage2, REM and wake are 93.33%, 77.79% 59.43% and 62.83% respectively, training time in the artificial neural network is 1350.7 second. Retained features of time domain include SDNN, RMSSD, SDDSD, NN50 and pNN50. The HF norm, VLF% and

5mins total power are three retained features in frequency domain.