智慧型醫學資訊系統

梁 勝 富

成功大學 資訊工程系暨醫學資訊所
人工智慧生技醫療創新研究中心

2020 年 11月 19 日

成大資訊系醫學資訊所

成員

* **Faculties：15**
  * Full Professors : 13
  * Associate Professors : 2
* **Students：45**
  * Master Program: : 35
  * Ph. D. Program ： 10

研究方向

* Artificial Intelligence for Medical Informatics
* Medical Signal/Image Processing
* Bioinformatics
* Biomedical Information Retrieval
* Medical Instruments
* Human-Machine Interface

科技部補助
人工智慧生技醫療創新研究中心
MOST Artificial Intelligence Biomedical Research Center

科技部專案支持於2018年在成功大學成立

中心簡介

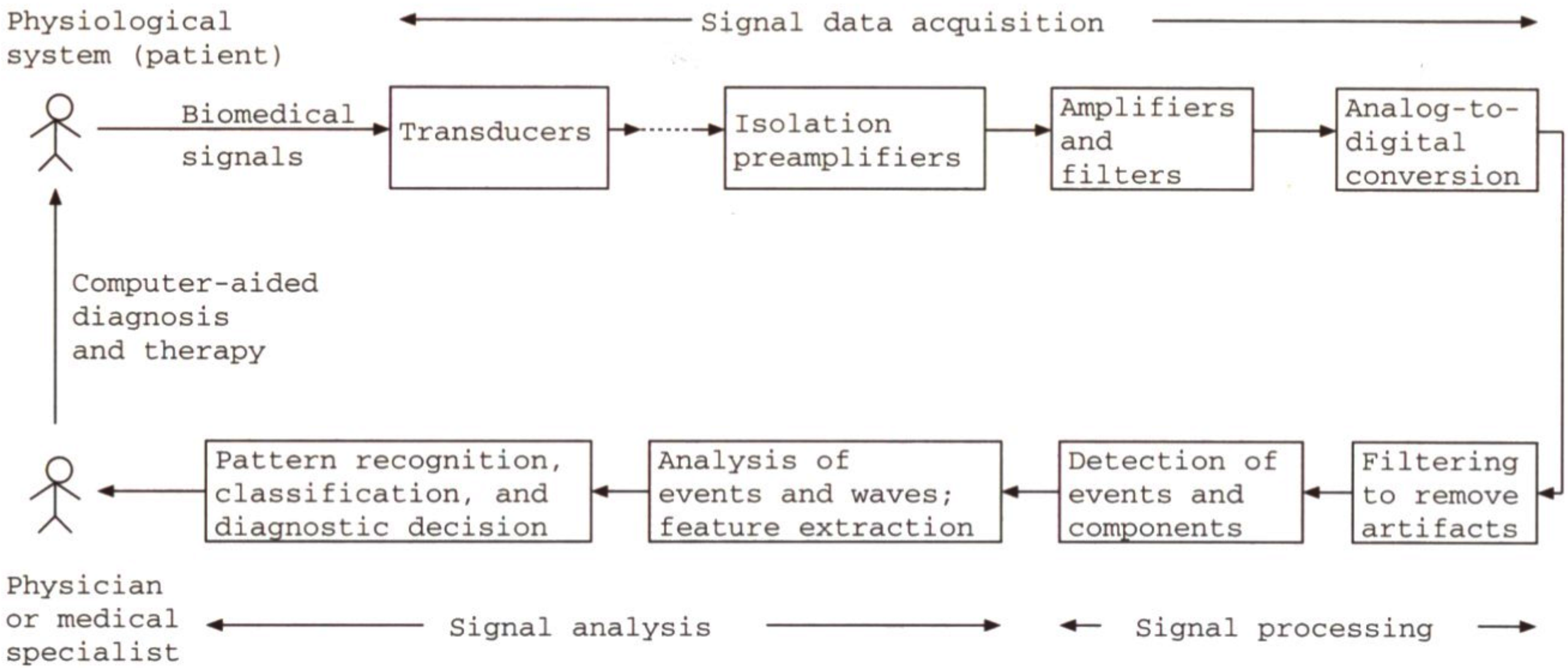
中心致力於生物醫學和人工智慧多領域整合，促進開發前瞻技術、建置相關大數據資料庫及深耕智慧醫療場域應用，透過跨學科、跨機構和國際級單位之合作，發展創新之AI解決方案及培育生醫產業所需AI跨域人才

發展領域

中心服務特色

- 鏈結產官學研醫機構、國際級研究中心
- 擴大跨領域共同合作，研發AI生醫關鍵技術與應用範疇協助智財法規規劃佈局與申請
- 協助臨床確效與認證程序
- 提供人才培育與產業交流
- 探索產業實際需求與AI解決方案
  提供實務與臨床支援
- 建立研究平台、技術及資料庫分享機制
  協助產業與國際之媒合技轉與新創發展

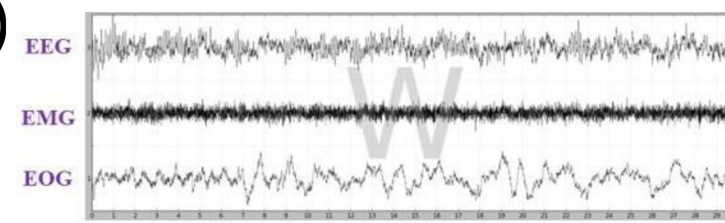
電腦輔助診療系統

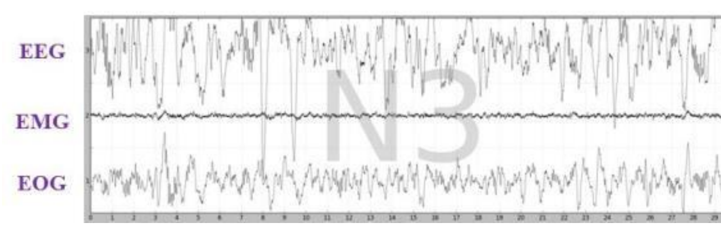

Physiological system (patient)
Signal data acquisition
Biomedical signals
Transducers
Isolation preamplifiers
Amplifiers and filters
Analog-to-digital conversion
Computer-aided diagnosis and therapy
Pattern recognition, classification, and diagnostic decision
Analysis of events and waves; feature extraction
Detection of events and components
Filtering to remove artifacts
Physician or medical specialist
Signal analysis
Signal processing

健康感測-穿戴式睡眠活動紀錄儀

- 人的一生約有三分之一的時間處於睡眠狀態
- 台灣睡眠醫學學會（2015）針對國人的睡眠調查結果，台灣慢性失眠盛行率為20.2%(約1/5)，全台逾400萬人
- 在臨床診斷上常以多重睡眠生理記錄儀(Polysomnography, PSG)收錄病患整晚的睡眠生理訊號，觀察患者的睡眠品質

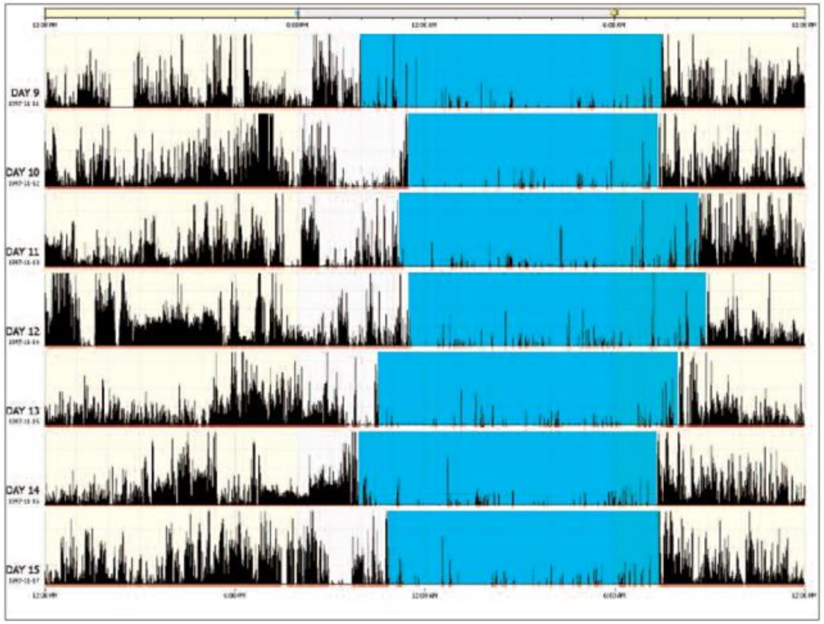
(www.neurocode-ag.com/homepage.html)





睡眠活動紀錄儀

- 運作原理
  - 利用運動感測器紀錄睡眠過程中使用者的姿態變化，進而估測使用者之清醒與睡眠階段
- 特點
  - 方便使用、減少干擾、與日常用品完美結合
  - 可記錄長期睡眠活動紀錄
  - 成為穿戴式裝置必備功能

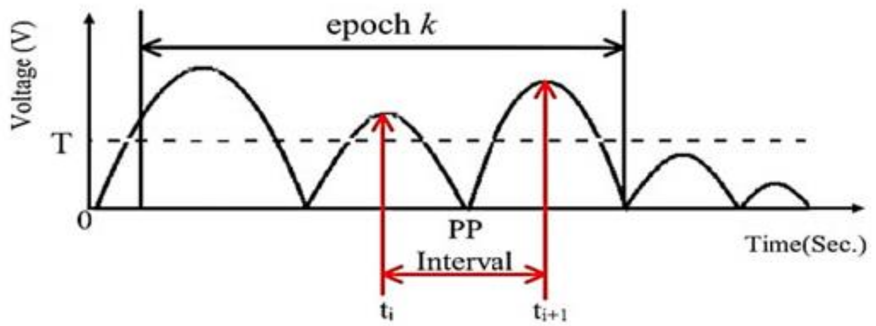


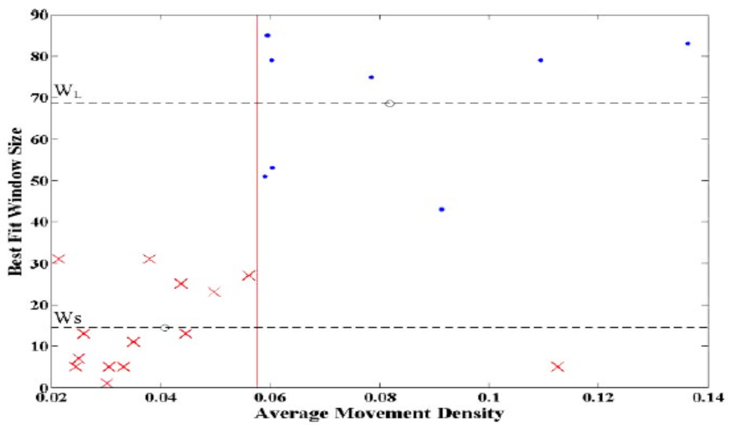
Normal sleeper

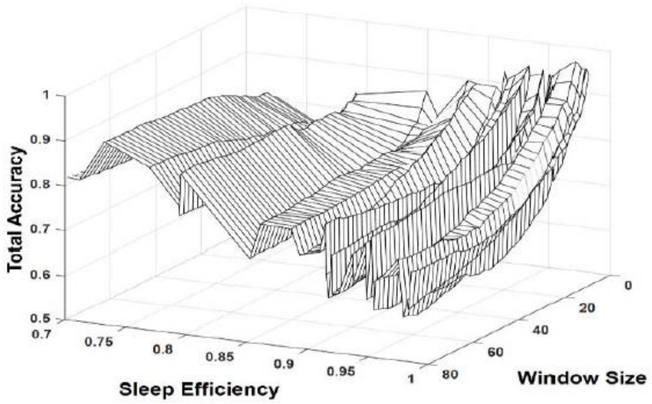
Actigraphy Reference Guide-Philips Respironics

智慧邊緣計算–清醒睡眠判讀

- Efficient actigraphy system
  - low sampling rate (1 Hz)
  - low data rate (1 channel)
- New features
  - peak-to-peak interval
  - movement density
- Adaptive windowing





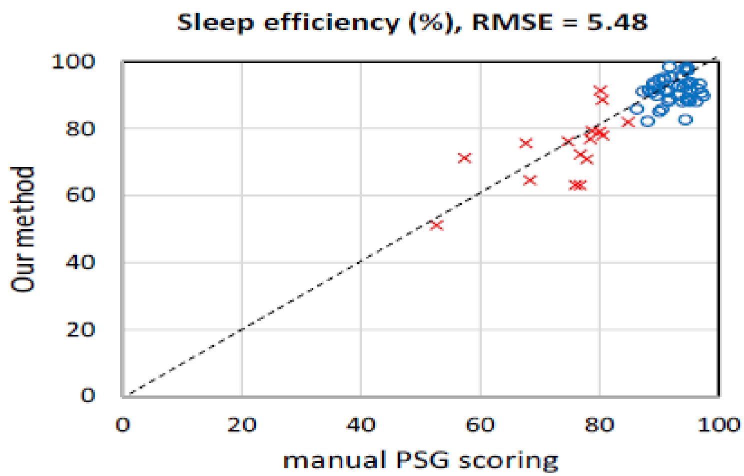


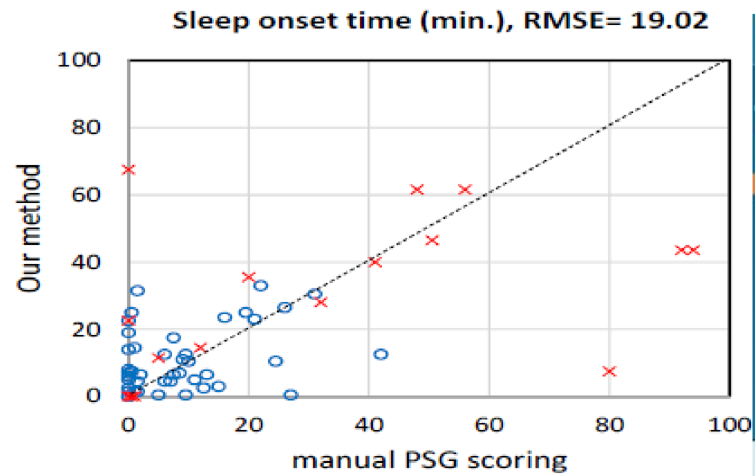
"This is of great clinical and research interest."

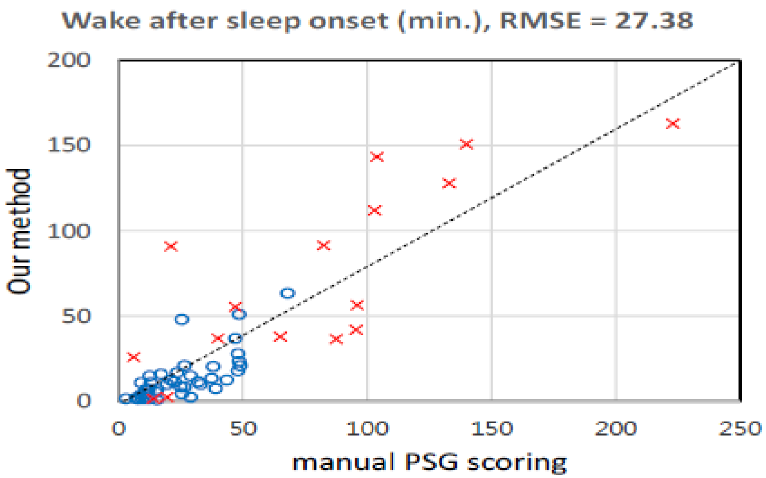
"An original, novel, innovative method is used."

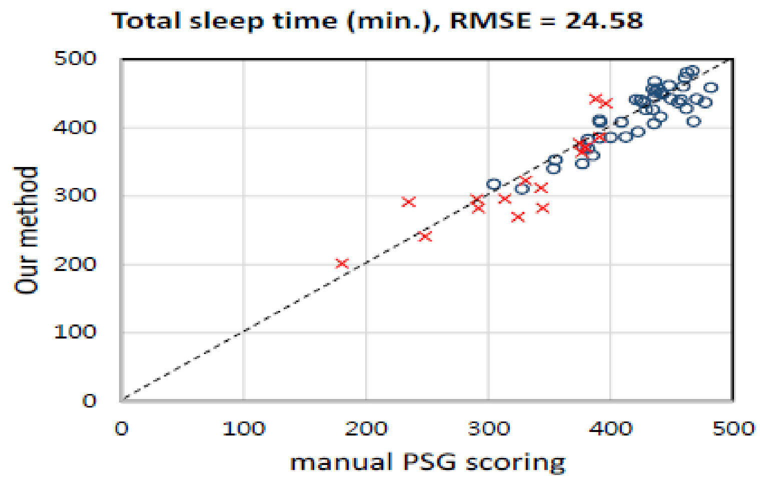
"Thank you for your contribution to science and engineering" (review comments IEEE TBME 17)

效能驗證







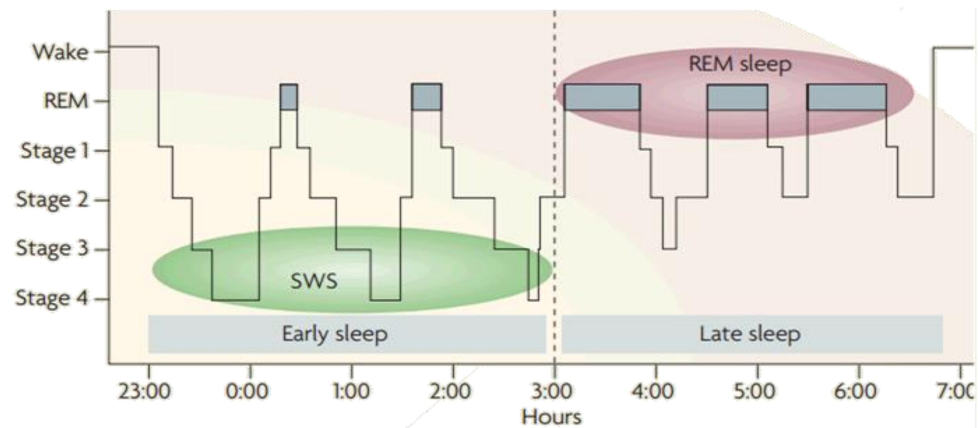


X:subjects with good sleep efficiency (SE>=85)

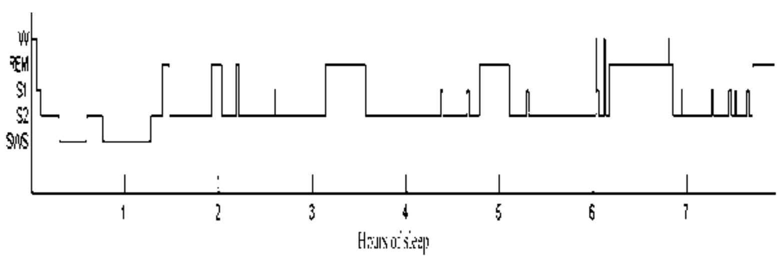
O:subjects with poor sleep efficiency (SE<85)

挑戰

- 睡眠活動紀錄儀目前不能進一步準確提供不同睡眠階段資訊，判斷完整睡眠週期
- 使用者無客觀方式瞭解裝置回報的資訊正確性

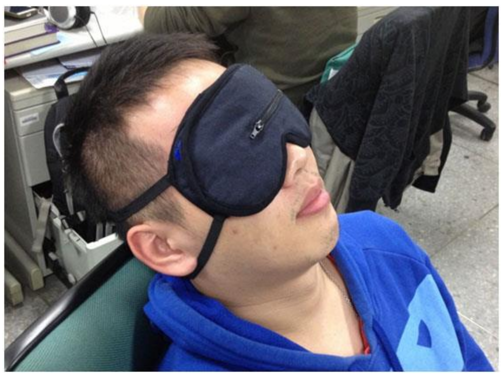


(Diekelmann and Born, 2010)

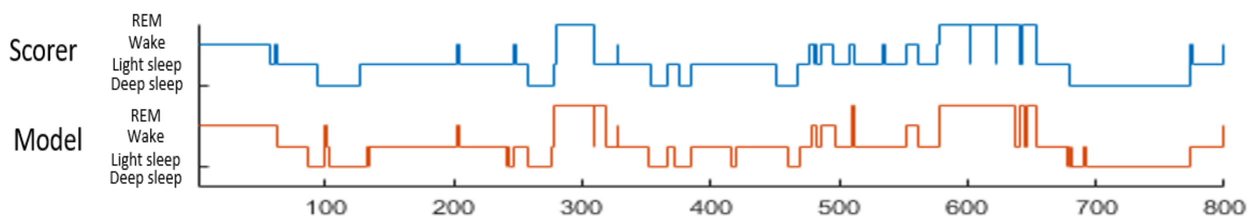


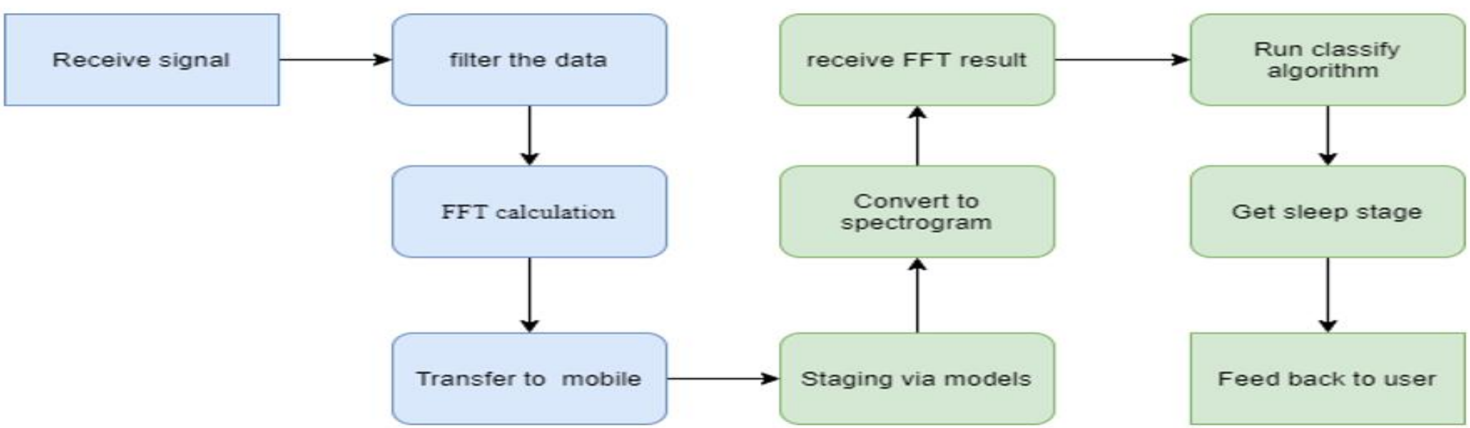
Novel Approach 智慧型睡眠眼罩

- 使用 1 EEG (Fp1) , 1 EOG (R2) , 1 Ref (A1) 總計3個電極點，判讀結果就可達到極高一致性
- AI 模型使用 : MobileNet v2

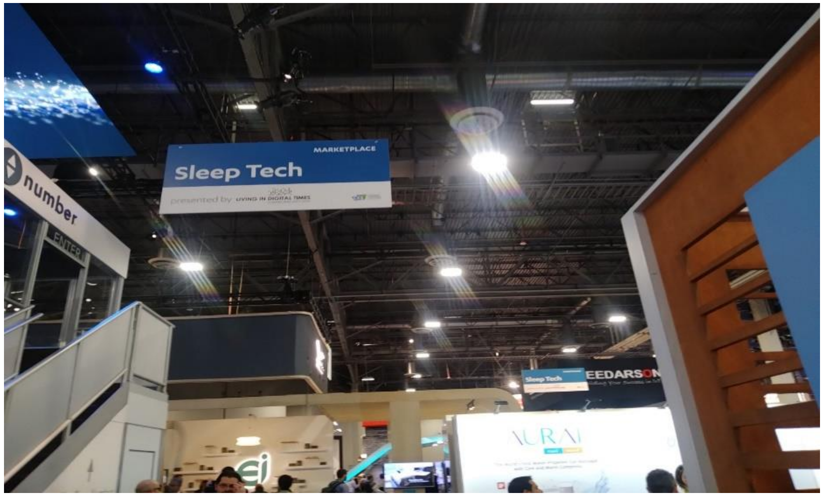


- 睡眠階段一致性達86.72%
- 睡眠指標一致性達93.29%
- 即時性自動判讀
- 輕便、簡易使用

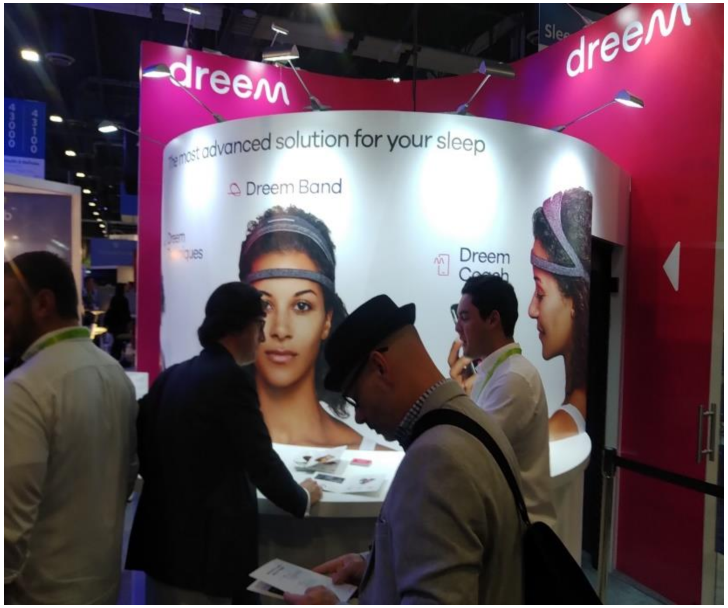




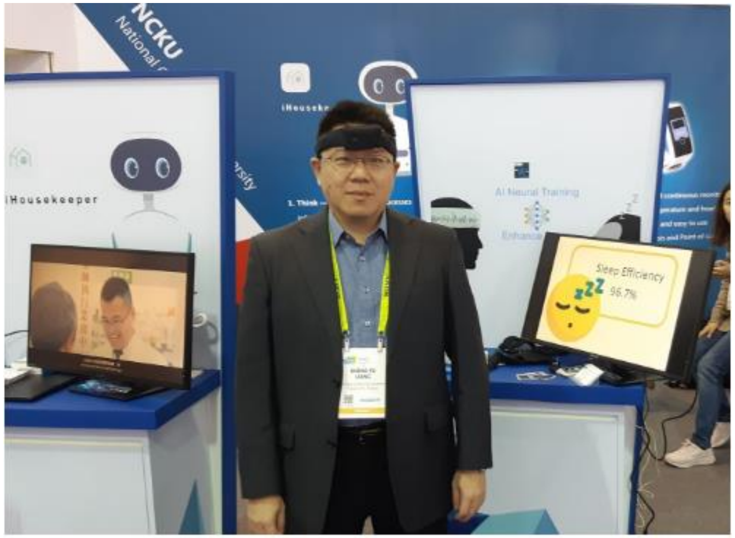
CES

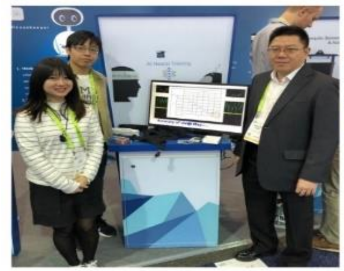

MARKETPLACE
Sleep Tech
number
AURA


Sleep better
Philips SmartSleep
Unleashing the power of your sleep
PHILIPS
HEALTH MATE
44100
44200
WebMD
amwell
ASA

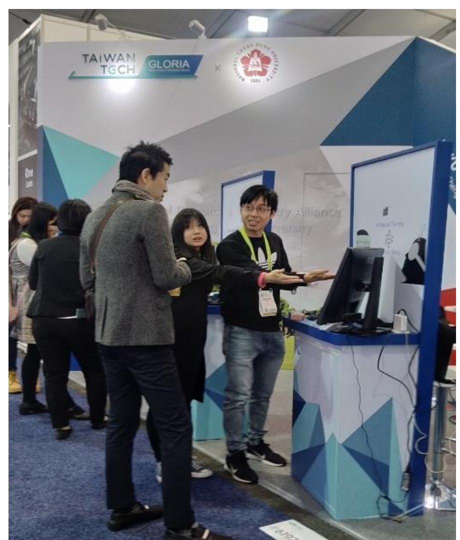

dreem
dreem
The most advanced solution for your sleep
Dreem Band

CES

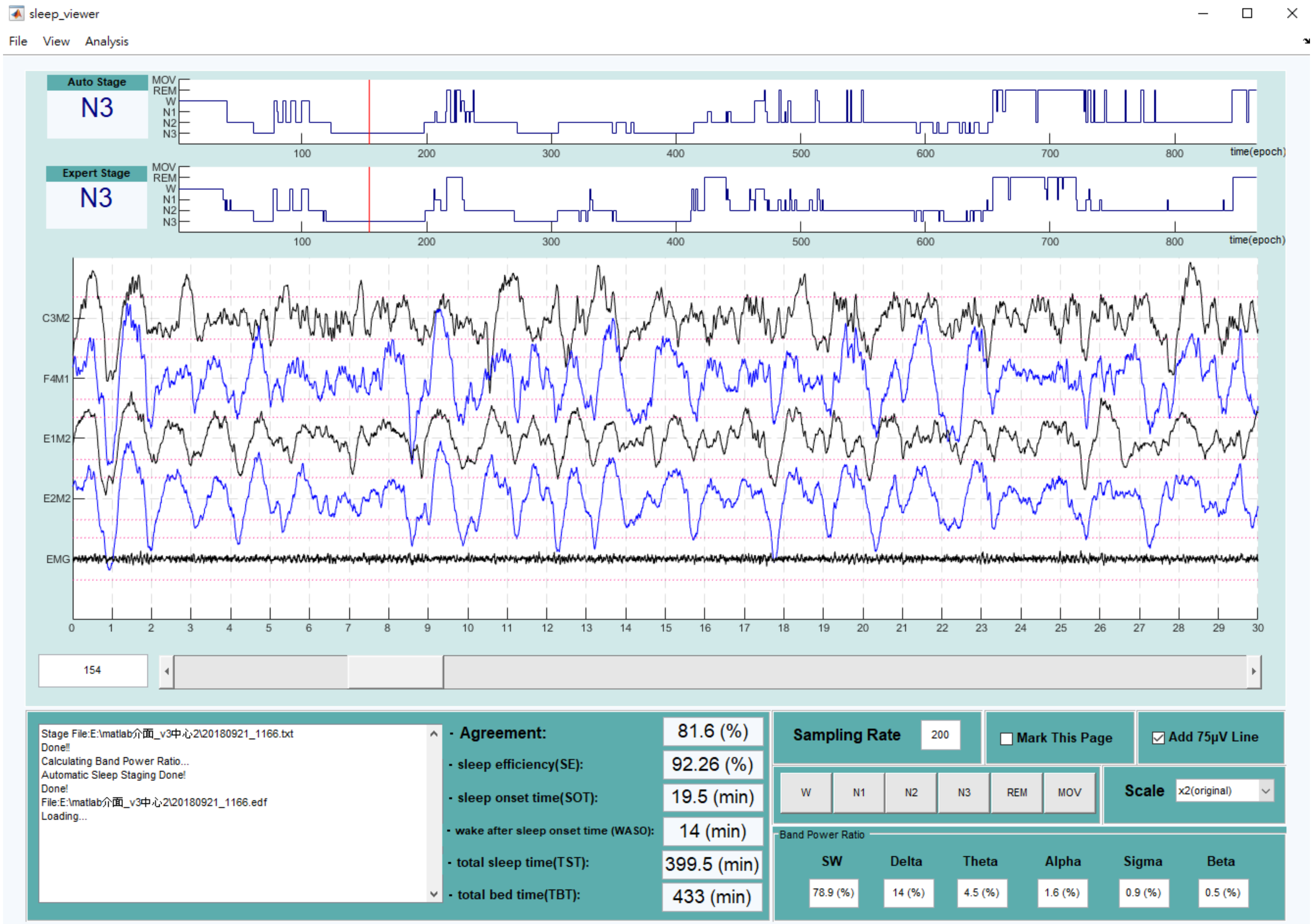




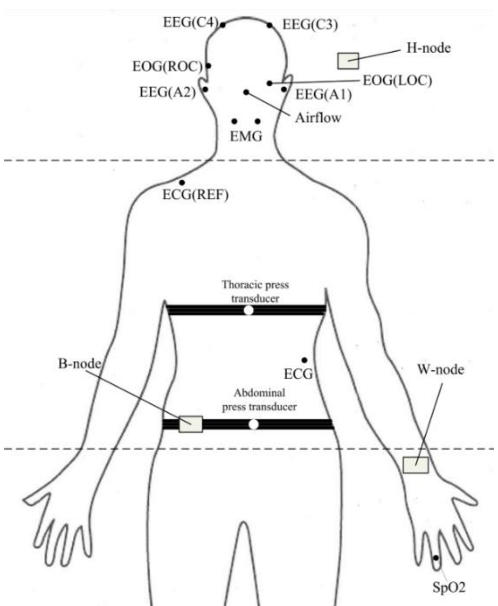
成功大學資工系梁勝富教授展示睡眠訓練BMW系統



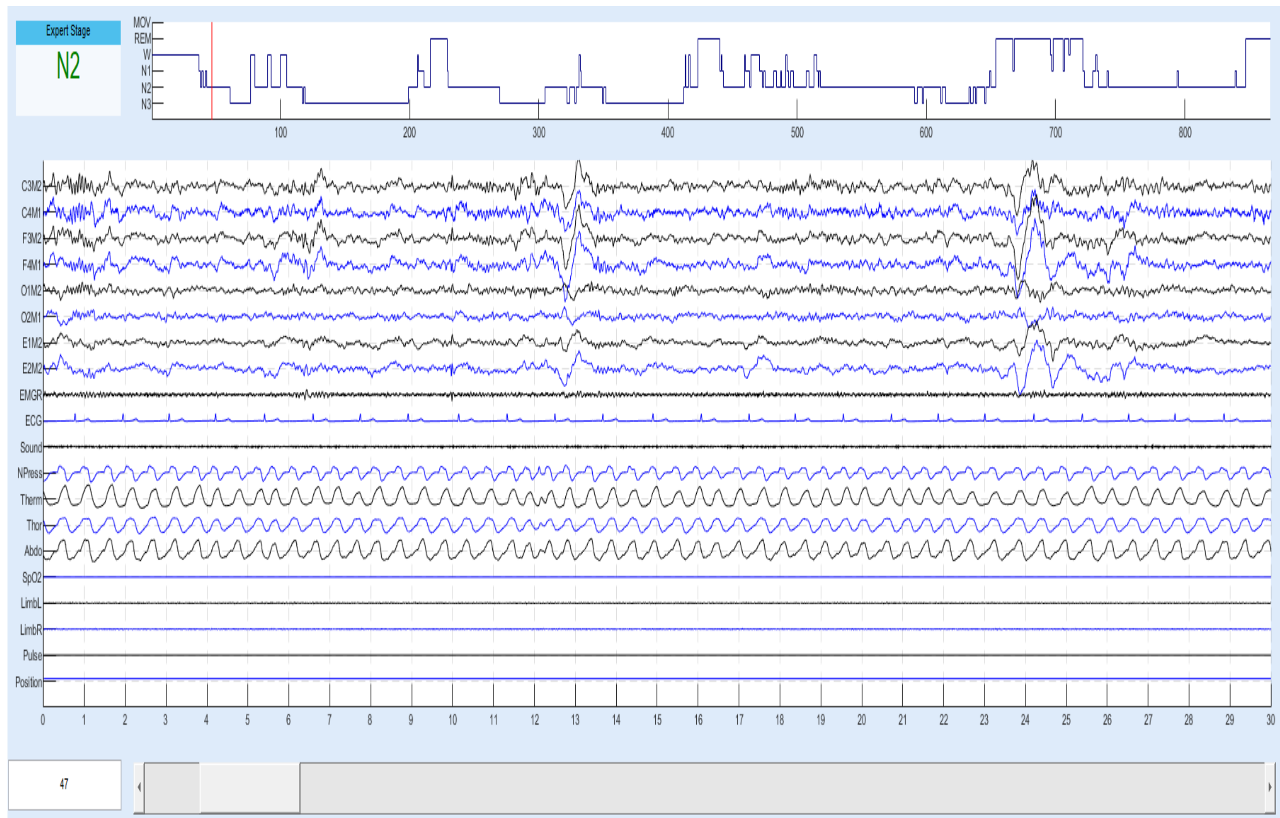
輔助診斷-睡眠輔助判讀系統



睡眠生理紀錄



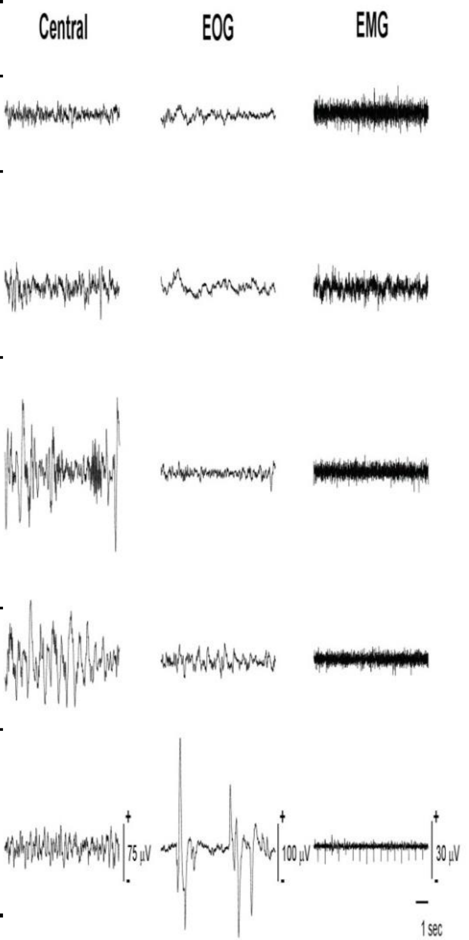
- All-night polysomnography (PSG)
  - electroencephalograms (EEGs),
  - electrooculograms (EOGs),
  - electromyograms (EMGs),
  - respiratory signals



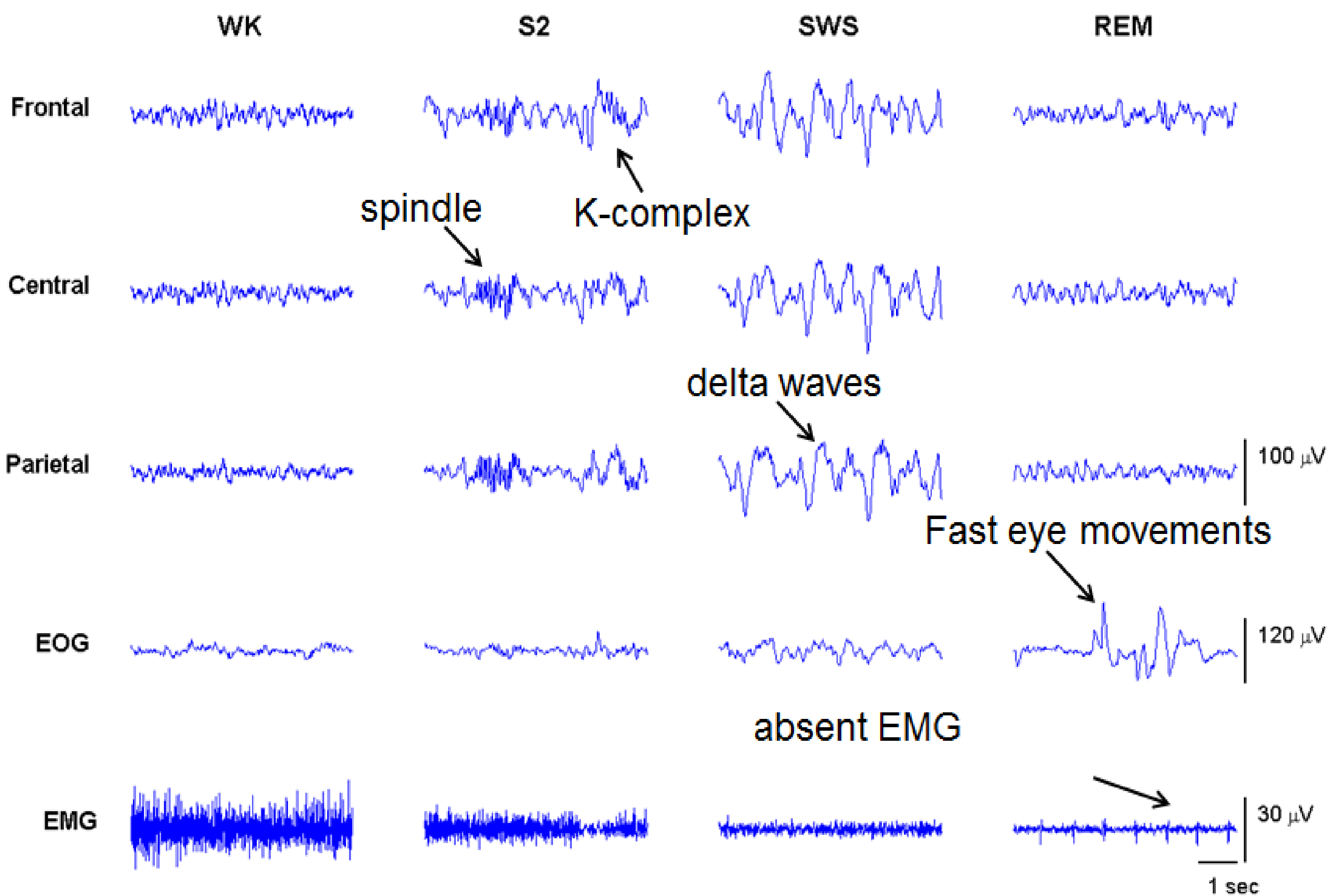
睡眠判讀

- American Academy of Sleep Medicine (AASM) Sleep Staging Criteria(Iber, 2007)
- AASM Inter-Scorer Reliability - Sleep stage agreement averaged 82.6%

Sleep Stage	Scoring Criteria
Waking	> 50% of the epoch has alpha (8-12 Hz) rhythm.
N1	If alpha rhythm is attenuated and replaced by low amplitude, mixed (2-7 Hz) frequency activity for more than 50% of epoch with slow eye movements (SEM) and vertex sharp waves (V waves).
N2	If one or both of the following occur during the first half of that epoch or the last half of the previous epoch: a. One or more K complexes unassociated with arousals. b. One or more trains of sleep spindles.
N3	> 20% or more of an epoch consists of slow wave activity (0.5-2 Hz and peak-to-peak amplitude > 75 μV).
REM	a. Low amplitude, mixed frequency EEG (2-7 Hz). b. Low chin EMG tone. c. Rapid eye movement.

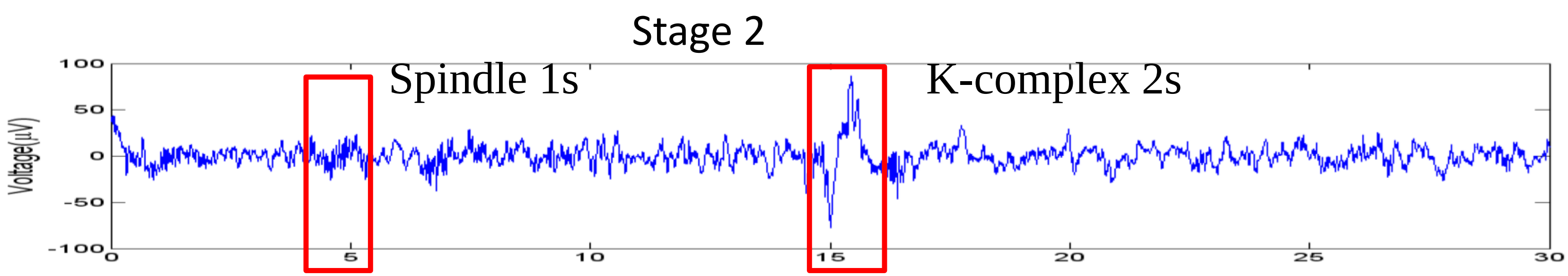


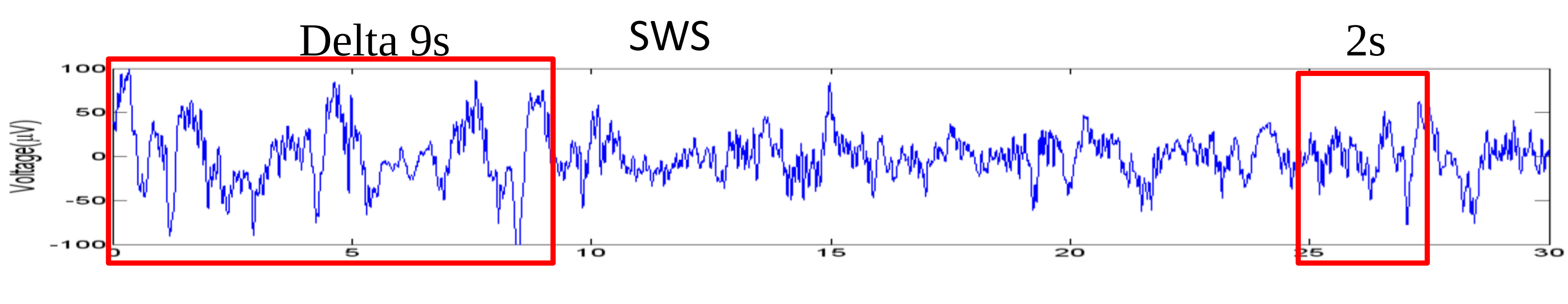
睡眠判讀


WK
S2
SWS
REM
Frontal
Central
Parietal
EOG
EMG
spindle
K-complex
delta waves
Fast eye movements
absent EMG
100 µV
120 µV
30 µV
1 sec

睡眠判讀

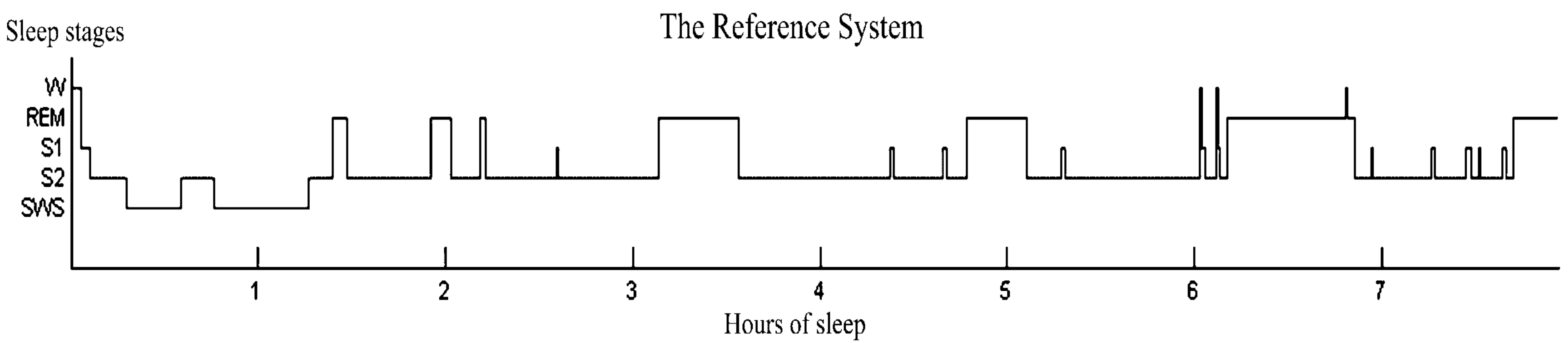
- Signal Characteristics
  - K-complex and spindle in stage 2, are often less than 2 sec.
  - The SWS epoch has > 6-s delta activity and Stage 2 may contain < 6-s delta activity.

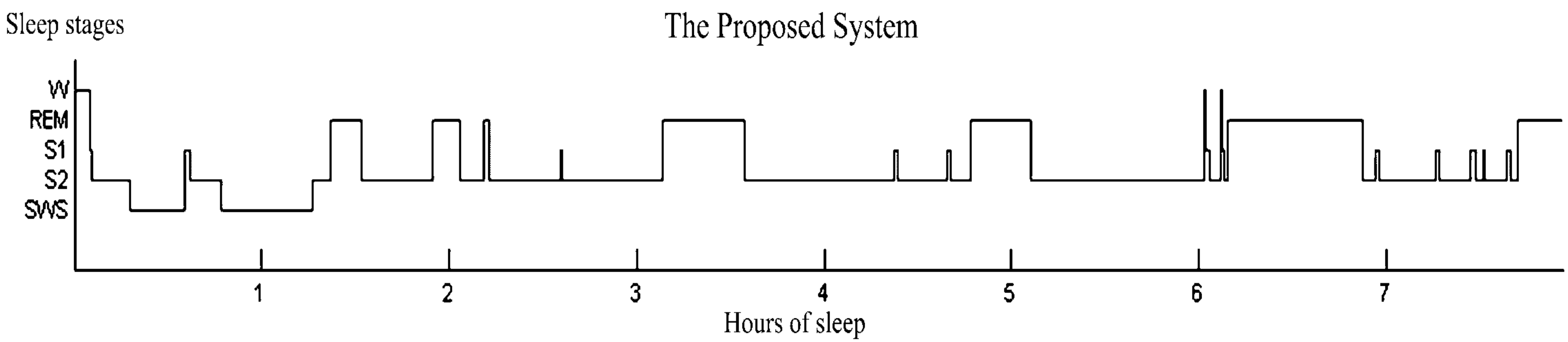




Automatic Sleep Scoring

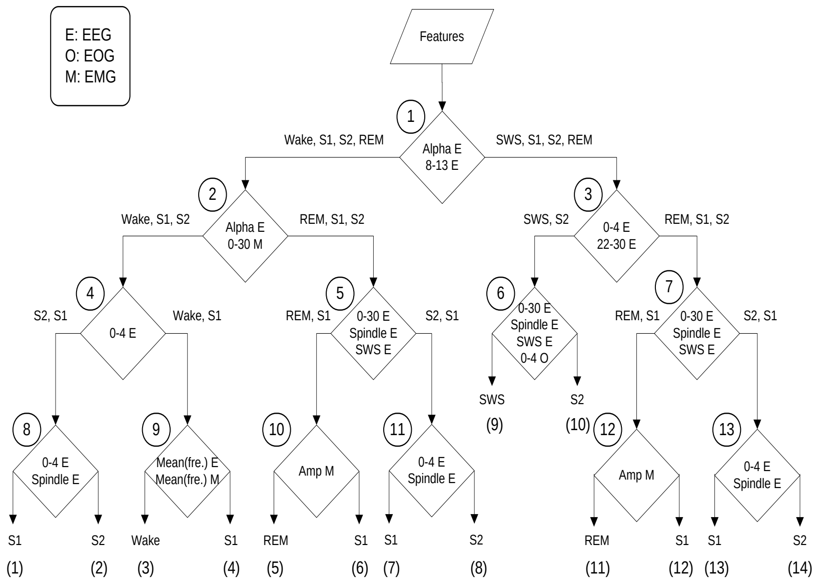
- Manual scoring is a time consuming and subjective process.
- The reliable computer-assisted tools for clinical staff to increase the efficiency of data scoring are desired.

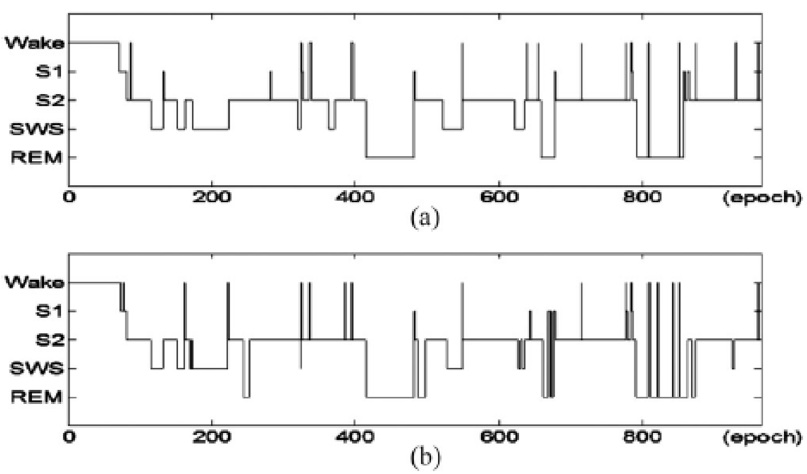




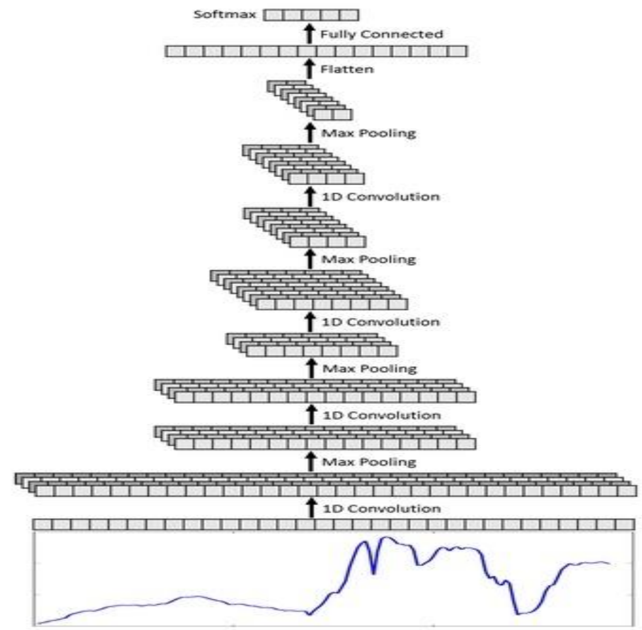
AI Models

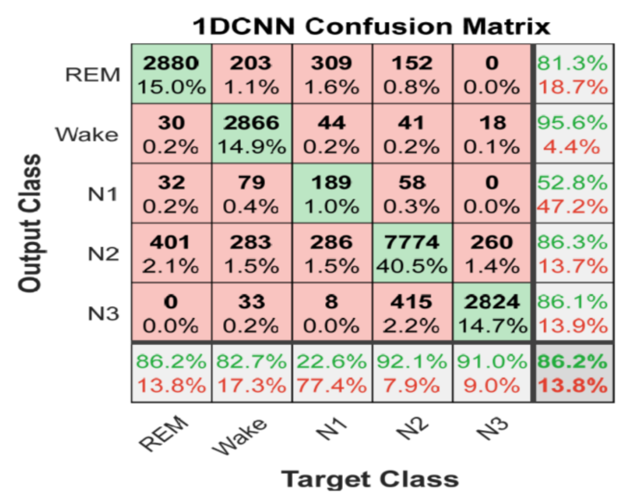
Decision Tree





CNN





The Challenge

- The overall agreement should be higher than the inter-scorer agreement (>82.6)

- Most existing methods only reported the final staging results.
  - The experts cannot understand the rules.
  - The reliability is not convincing.

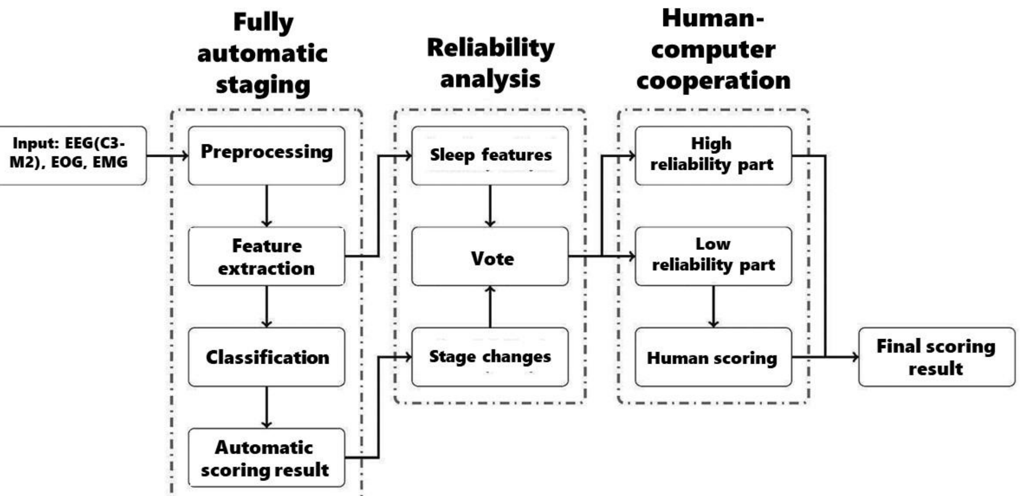
- All or None: so the experts always rescore the data to obtain the reliable results.
  - the automatic scoring methods cannot cooperate with the scorer to effectively reduce the amount of time and effort for scoring.

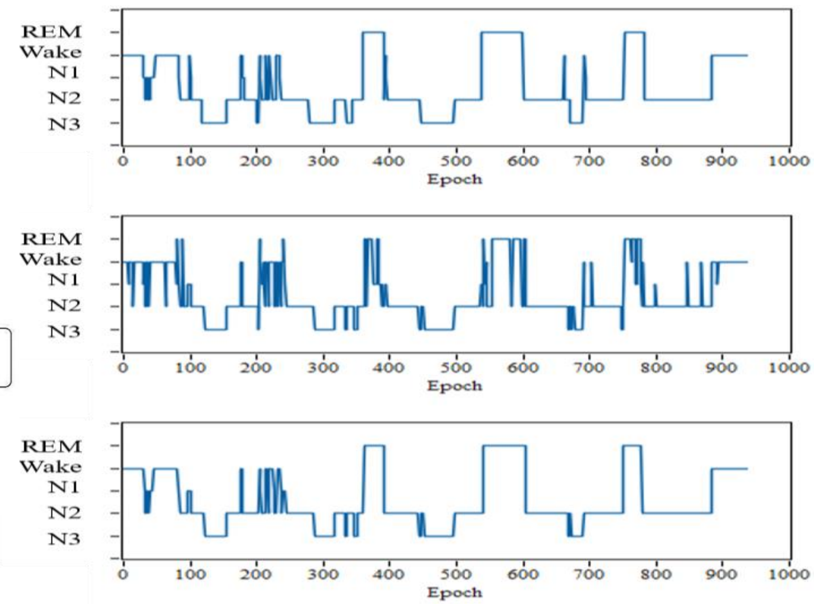
Human-Computer Collaborative Medical Systems

HCSS system

practically reduce
the manual scoring time

reliable and acceptable results



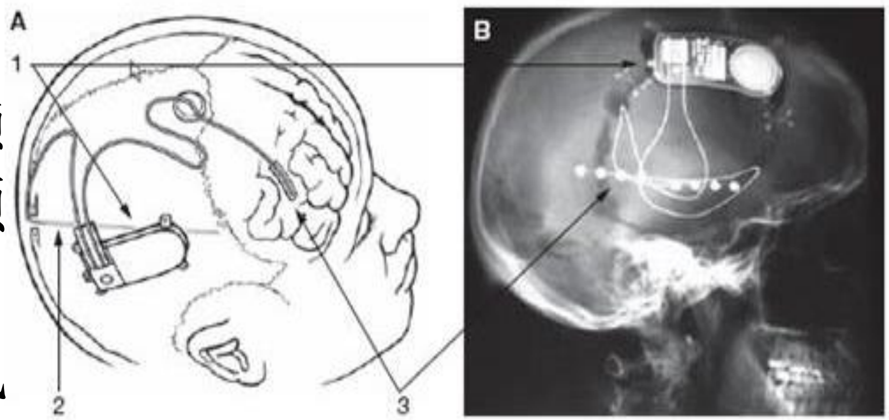


"This is really a nice work with many **good ideas**. You try to **solve one real problem** as is the introduction of automatic methods in everyday clinical practice, and you do it with a **simple** solution that should **not scare technicians**."

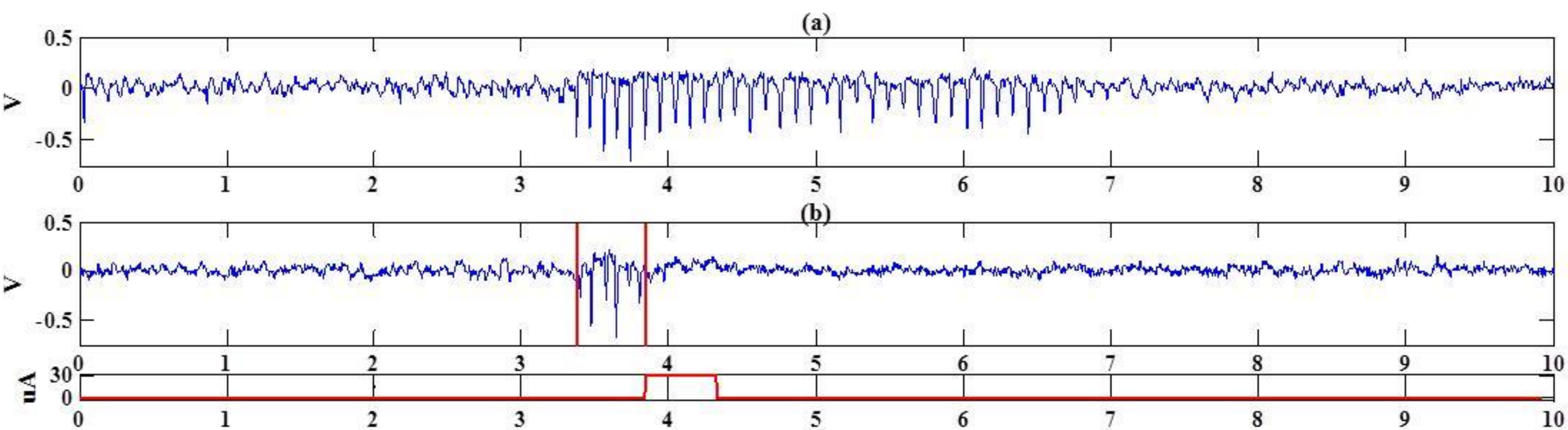
- PSG Data from 30 subjects.
- The final scoring results are reliable (>82.5%).
- The manual scoring time can be reduced(>50%).

症狀治療–反應式顱內電刺激器

- 顱內電刺激器把外部刺激（如電流）直接送入大腦以抑制不正常狀態。
- 有些嚴重的帕金森氏症與癲癇患者在藥物治療遇到瓶頸，利用植入式顱內電刺激器改善病患的治療成效，已成為新的治療技術。

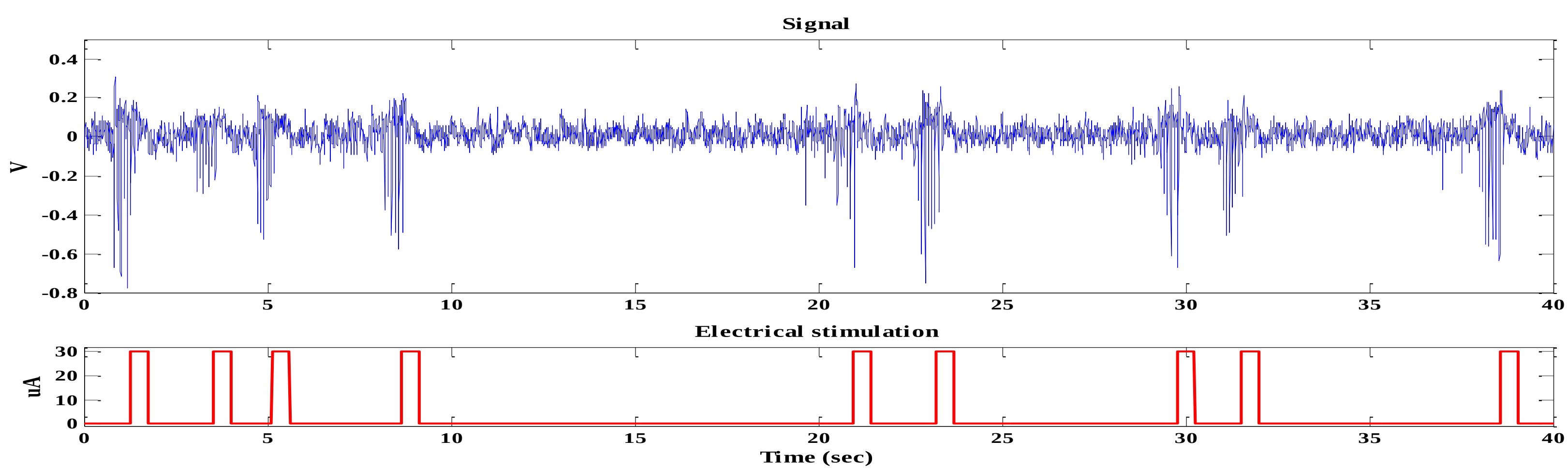


Neuropace neurostimulator



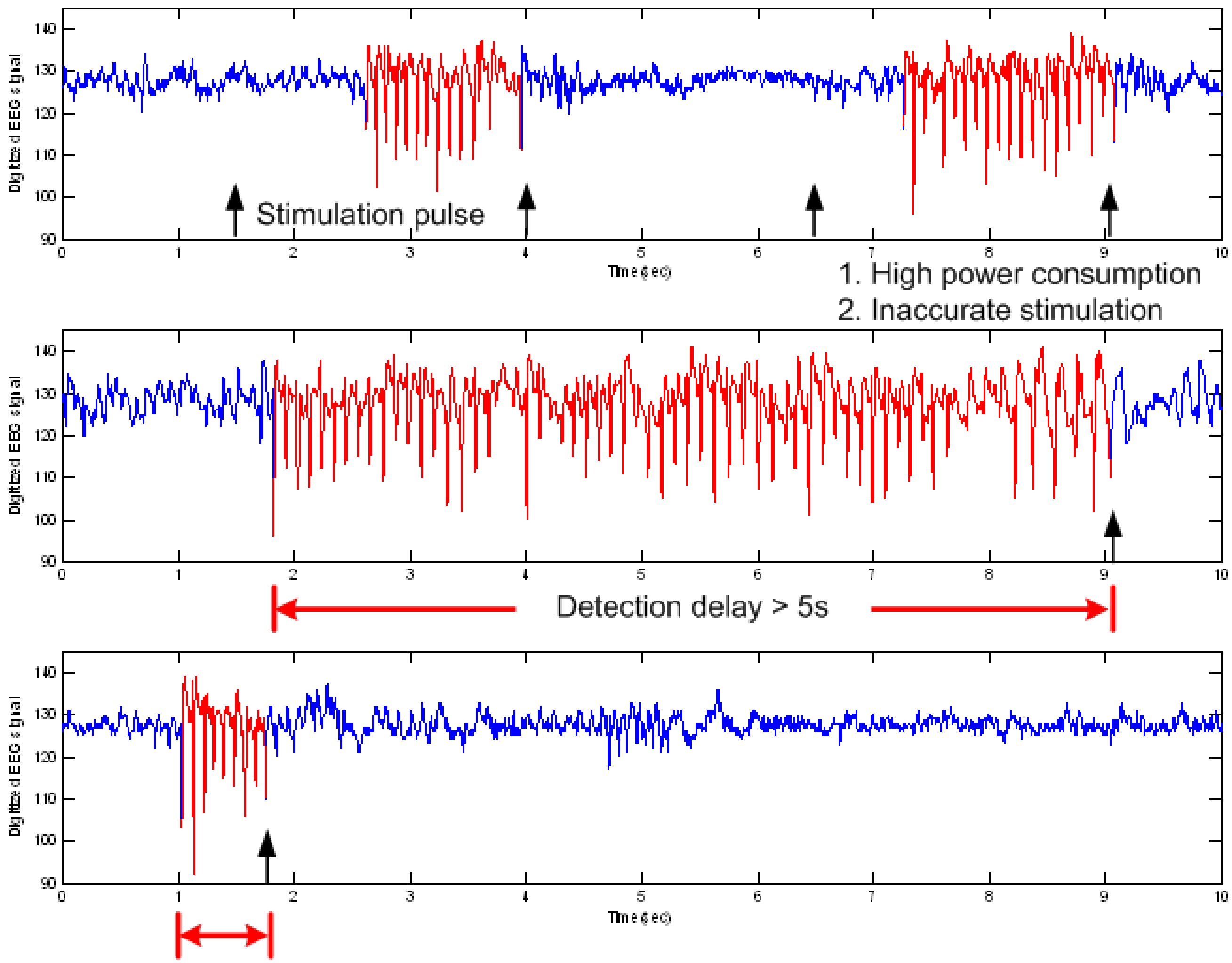
反應式電刺激器運作基礎

- 癲癇是腦細胞異常同步放電所造成的腦功能失調症，其發作時間不可預期，發作時常會有暫時失去意識、抽搐等症狀。
- 反應式電刺激器運作方式
  - 持續監測腦波訊號，偵測癲癇發作
  - 當癲癇發作，立即啟動電刺激器，抑制大腦異常放電
  - 當腦波恢復正常狀態時，則關閉電刺激器

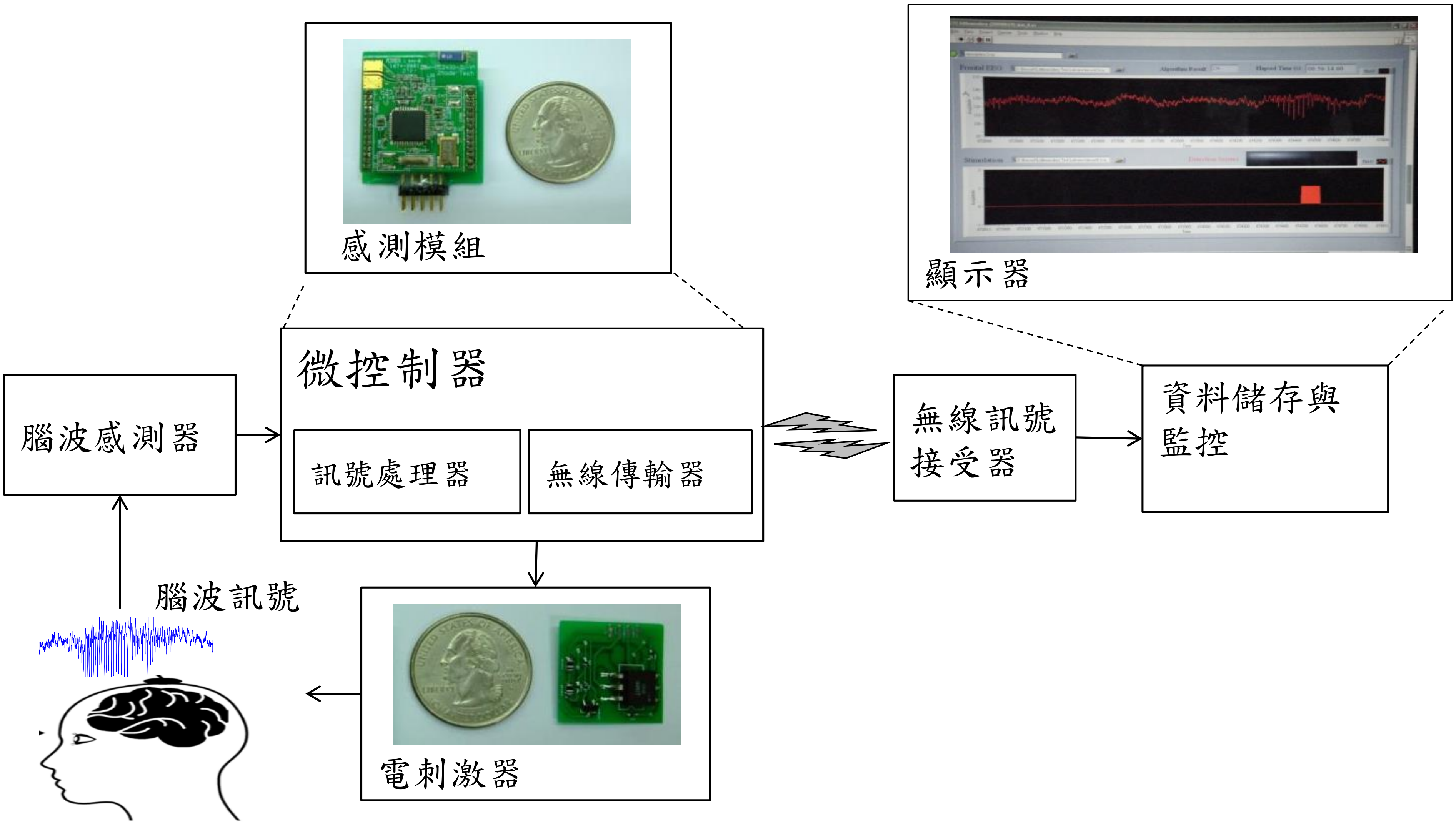


固定式與反應式電刺激比較

- 固定式
- 反應式



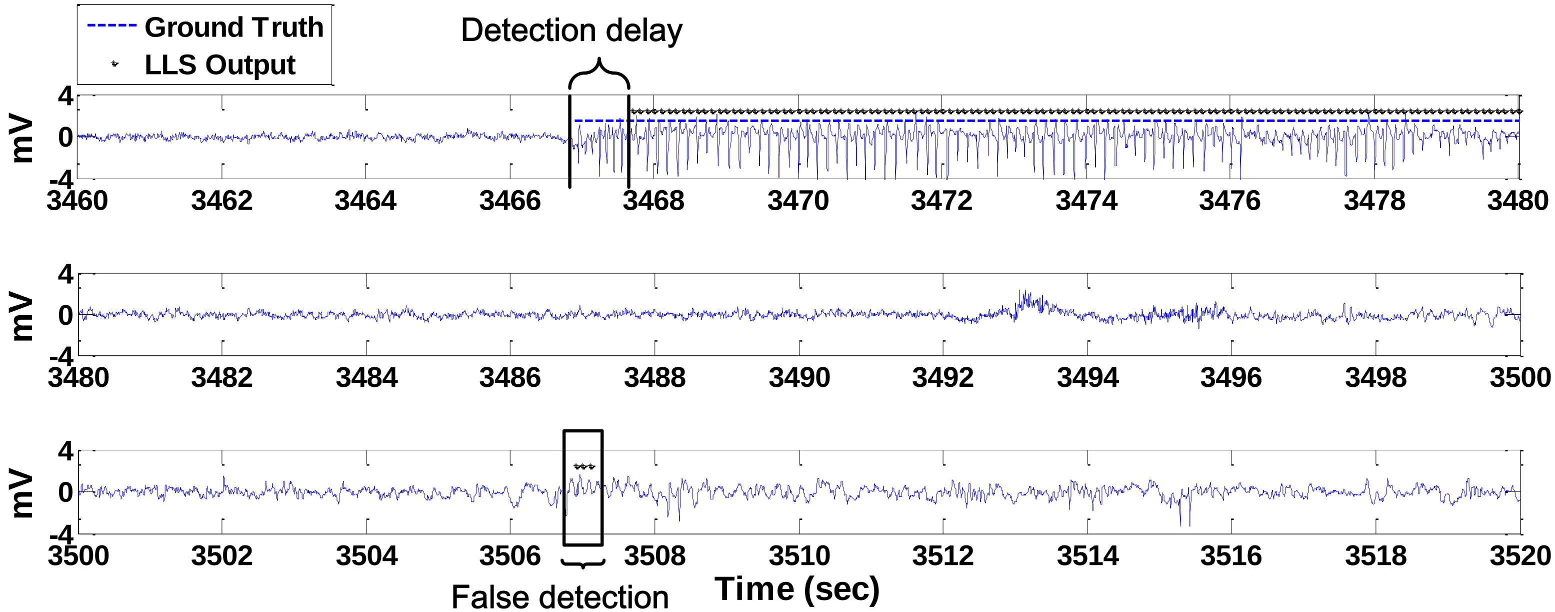
反應式電刺激器基本架構



反應式電刺激器特性與要求

- 微小化
  - 才能裝置在患者身上，而不至於影響到日常生活
- 可長期運作
  - 若常需開刀以換電池，會嚴重影響患者的生活

- 偵測準確率高且反應快
  - 癲癇偵測率高，減少疏漏
  - 減低誤判，以免在正常狀態下啟動電刺激器
  - 儘速偵測癲癇，發作快結束才偵測到，就太遲了

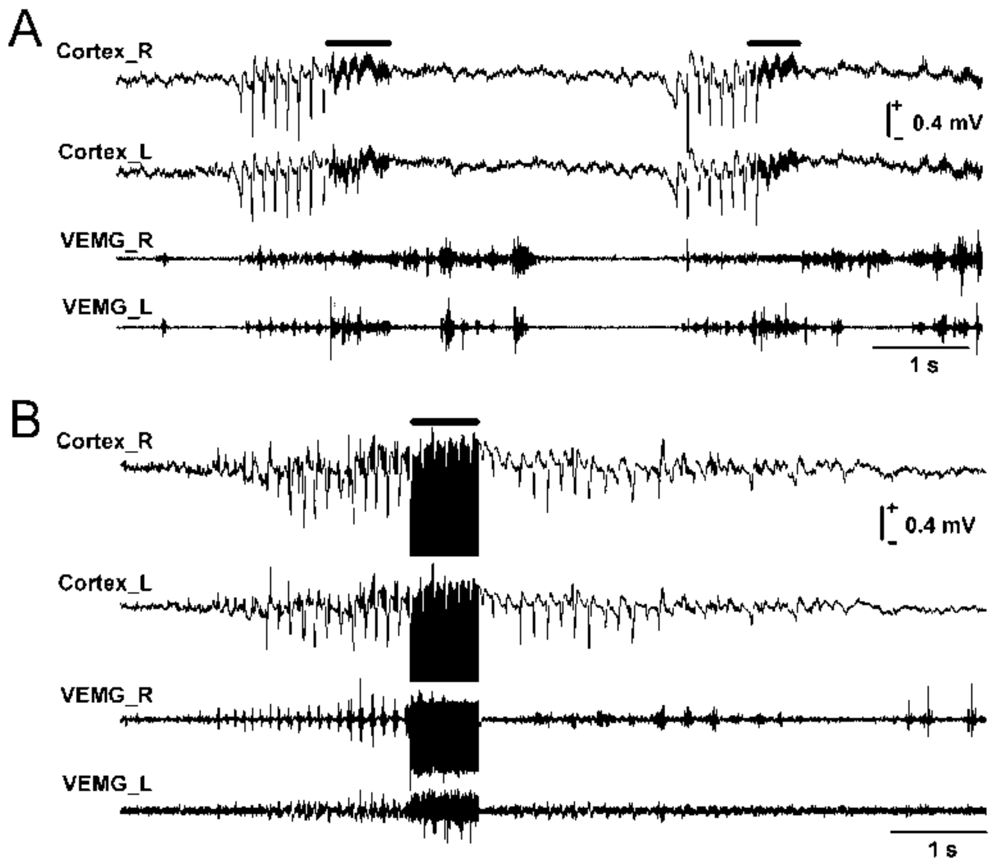


有效抑制癲癇的電刺激參數

- 測試不同設定，以獲得有效的癲癇抑制參數

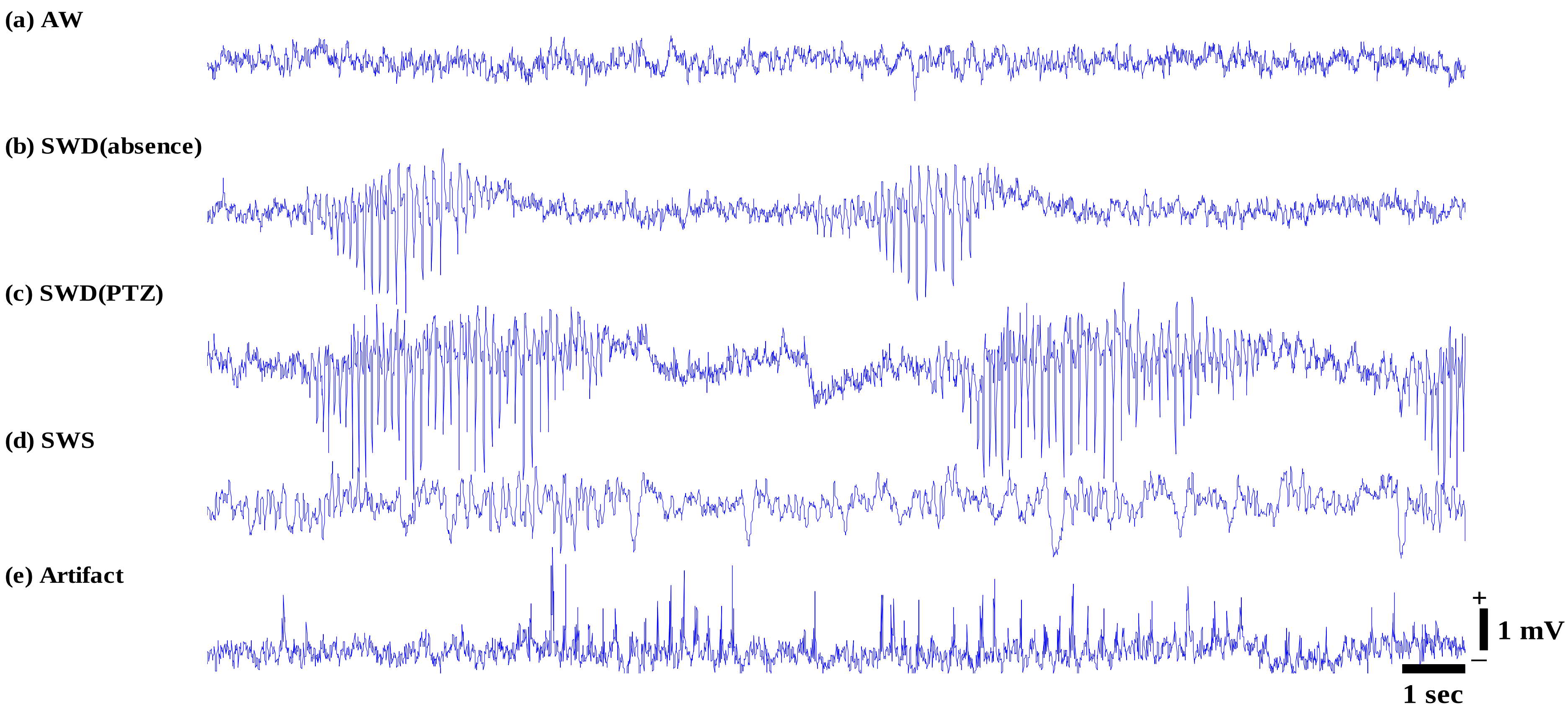
HFS: 800 Hz

MFS: 200 Hz

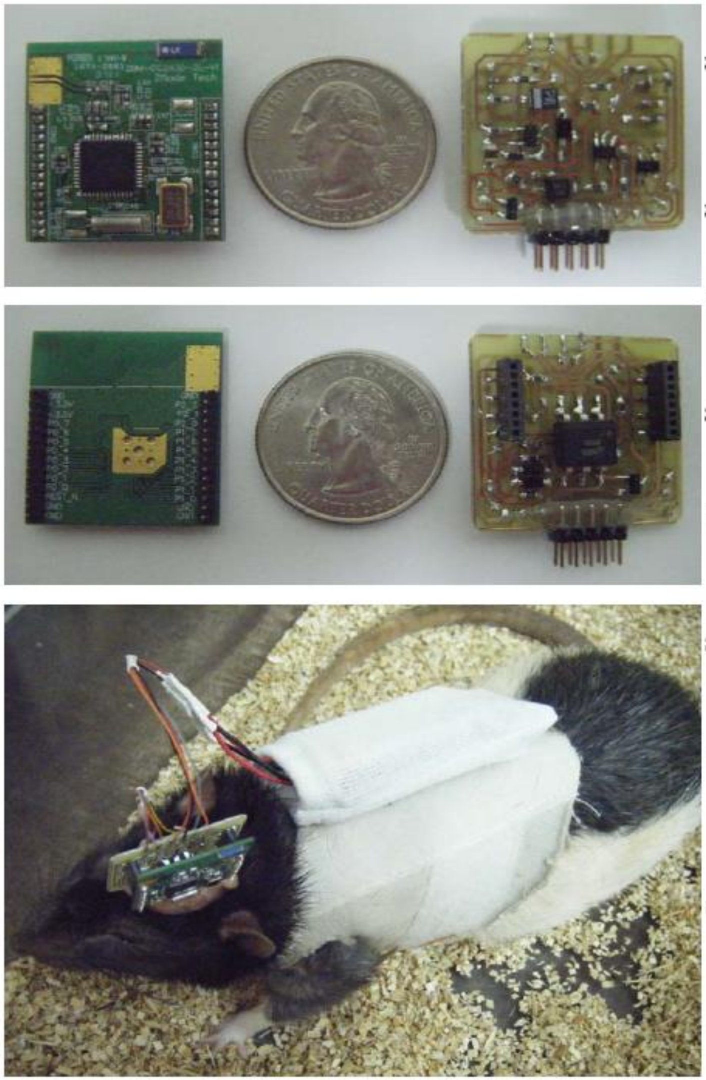


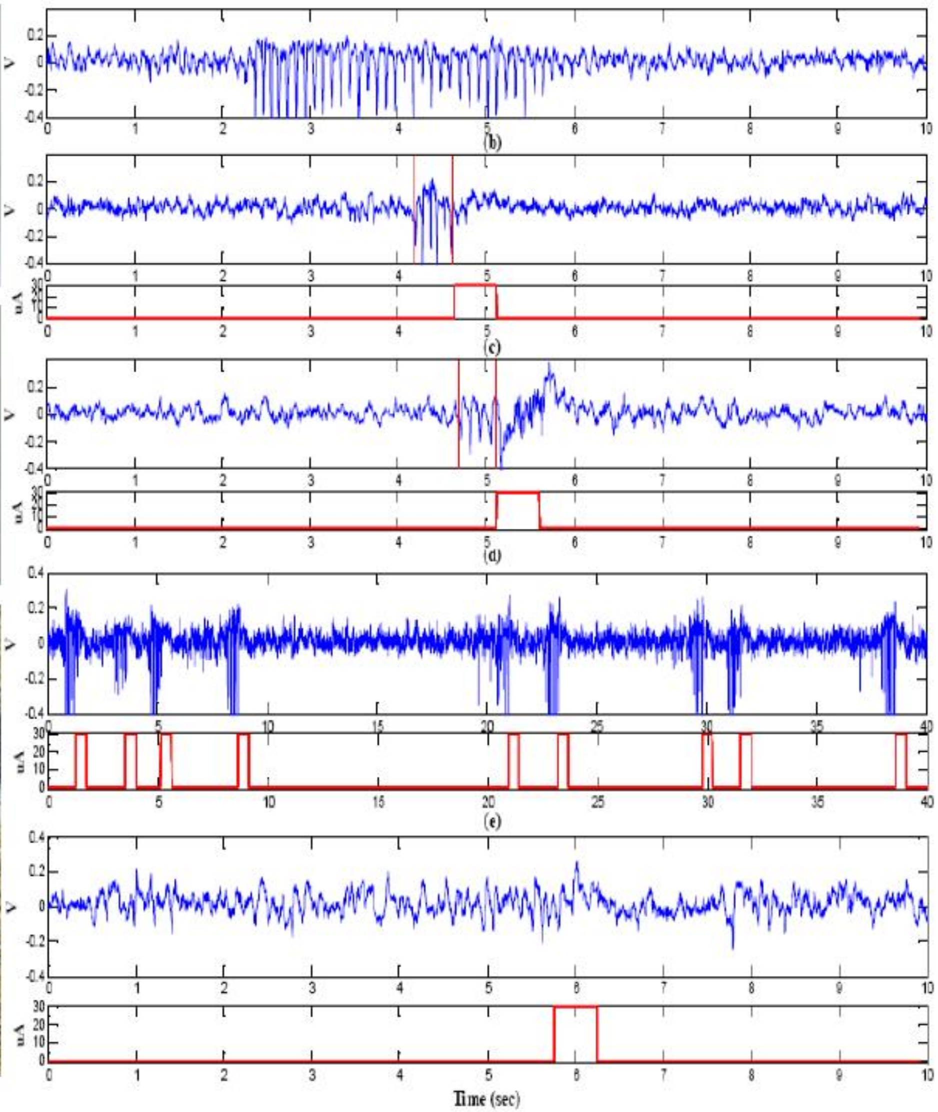
癲癇偵測技術的挑戰

- 如何在日常腦波訊號中，區別癲癇波與非癲癇波



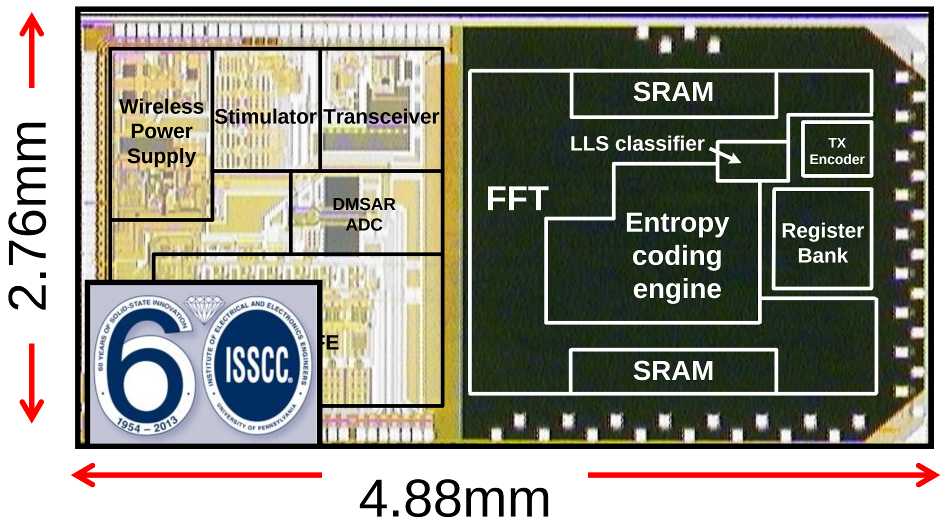
動物驗證實驗

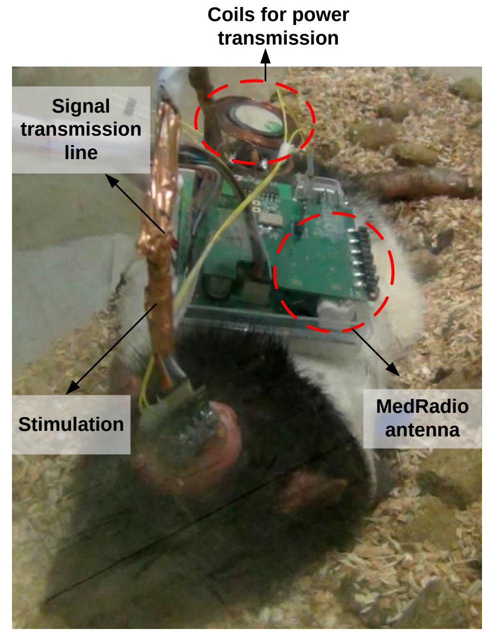


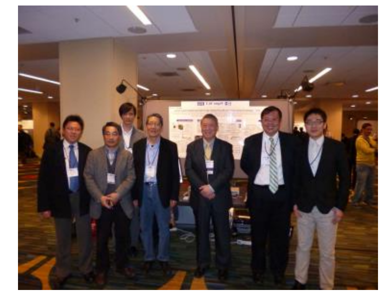


(Liang et al., *J. Neural Engineering*, 2011)

Integrated SoC published at ISSCC 2013 with Live Demo







16.1 A Fully Integrated 8-Channel Closed-Loop Neural- Prosthetic SoC for Real-Time Epileptic Seizure Control

Wei-Ming Chen[1], Herming Chiueh[1], Tsan-Jieh Chen[1], Chia-Lun Ho[1], Chi Jeng[1], Shun-Ting Chang[1], Ming-Dou Ker[1], Chun-Yu Lin[1], Ya-Chun Huang[1], Chia-Wei Chou[1], Tsun-Yuan Fan[1], Ming-Seng Cheng[1], Sheng-Fu Liang[2], Tzu-Chieh Chien[2], Sih-Yen Wu[2], Yu-Lin Wang[2], Fu-Zen Shaw[2], Yu-Hsing Huang[2], Chia-Hsiang Yang[1], Jin-Chern Chiou[1], Chih-Wei Chang[1], Lei-Chun Chou[1], Chung-Yu Wu[1]

[1]National Chiao Tung University, Hsinchu, Taiwan,

[2]National Cheng Kung University, Tainan, Taiwan

ISSCC 2013 Distinguished-Technical-Paper Award (Notified Dec 1, 2013)

未來發展

- 給電或充電技術
- 更有效的電刺激區域與刺激型態
- 癲癇偵測方法自我調整優化
- 研究長期使用電刺激器對大腦的影響
- 不同治療方式結合，以達到更佳的癲癇控制成效

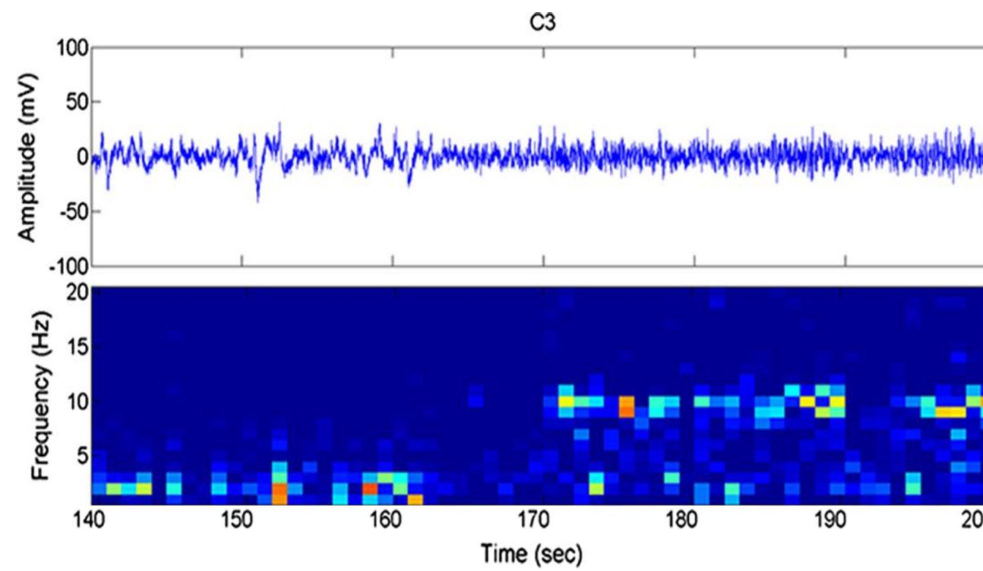
跨領域醫學資訊人才培育

- 從植入式小晶片與到醫療雲大數據，從生理訊號分析到電腦輔助診斷系統，從個人健康管理到公共衛生，資訊科技已無所不在，成為守護健康不可或缺的核心技術。
- 跨領域的人才培育與研究團隊的密切合作，將是資訊科技未來發展的趨勢與挑戰。

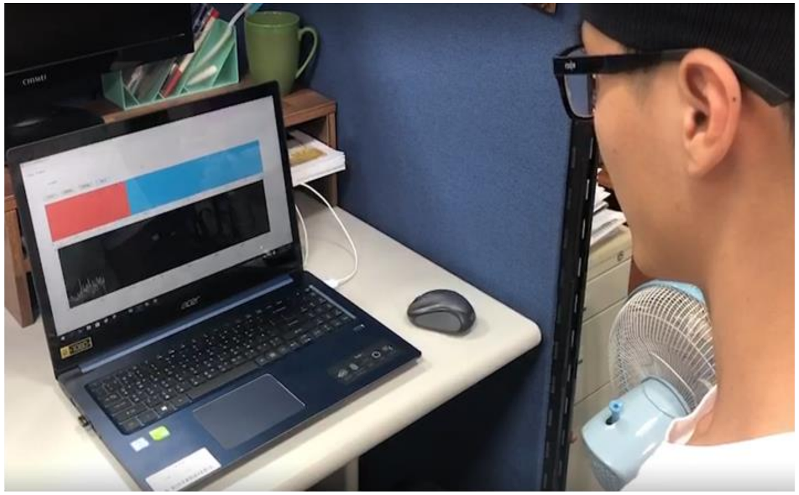
智慧型醫學資訊系統實作

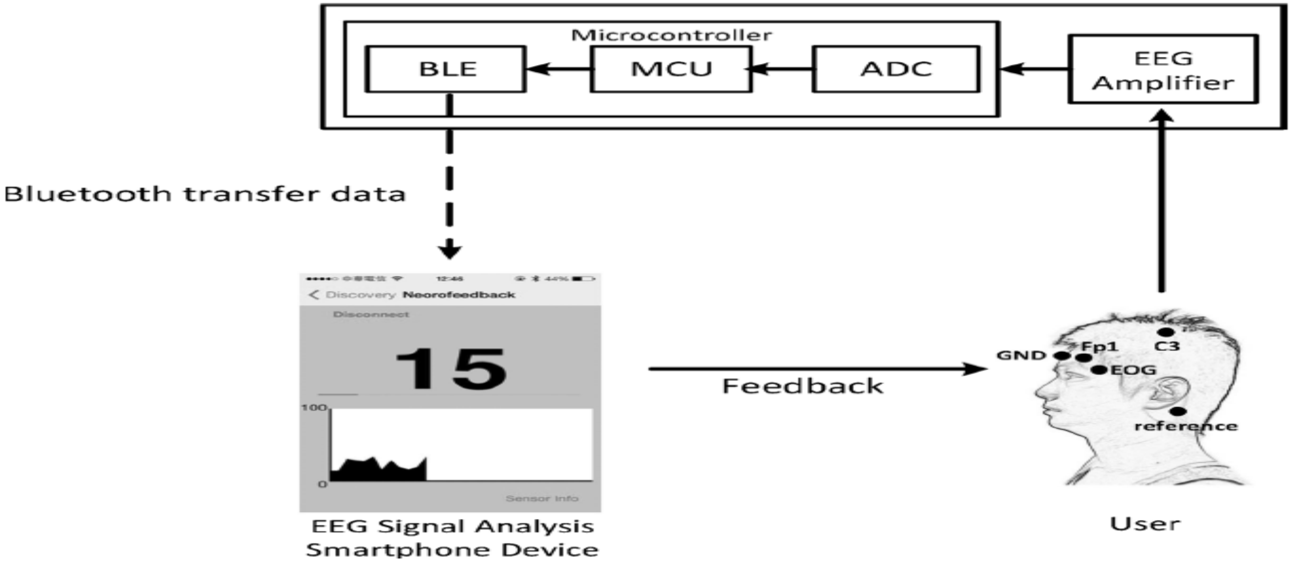
大腦調控-神經回饋訓練

- 神經回饋訓練為利用腦機介面來反應出大腦腦波的變化主要目的是透過操作型制約(operant condition)讓使用者可以察覺大腦特定的活性進而讓使用者能夠從中自我學習來控制自我的腦波



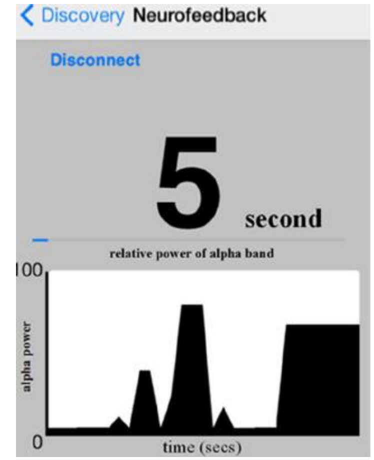
無線神經回饋訓練系統

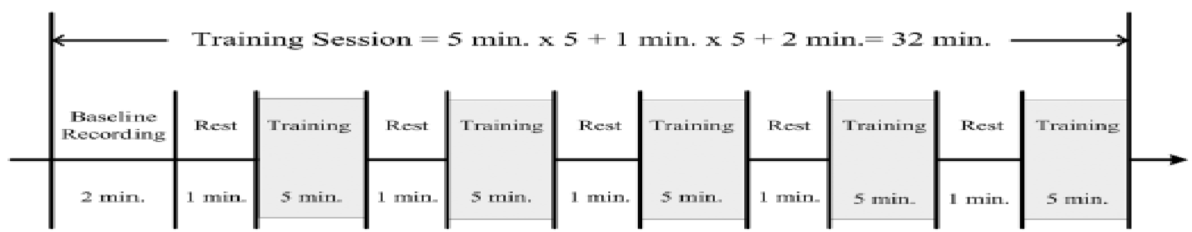


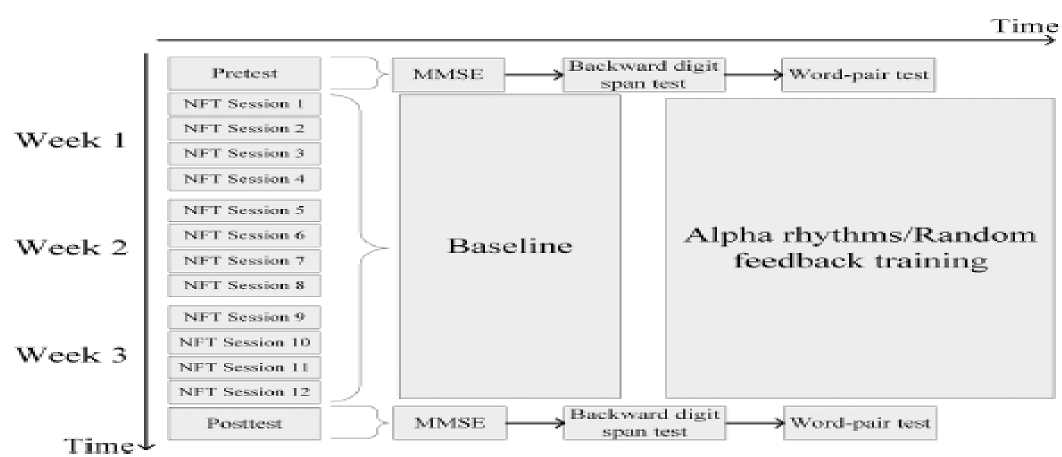

Microcontroller
BLE
MCU
ADC
EEG Amplifier
Bluetooth transfer data
Discovery Neorofeedback
Disconnect
15
100
0
Sensor Info
Feedback
GND
Fp1
C3
EOG
reference
EEG Signal Analysis Smartphone Device
User

NF Training

- Subjects:30(age 26 $\pm$ 3 years)
- Groups:
  - Alpha, n = 15
  - Ctl, n = 15
- 12 training sessions in 3 weeks (4 sessions/week).
- 5 blocks (5 min. for each block) in each session.



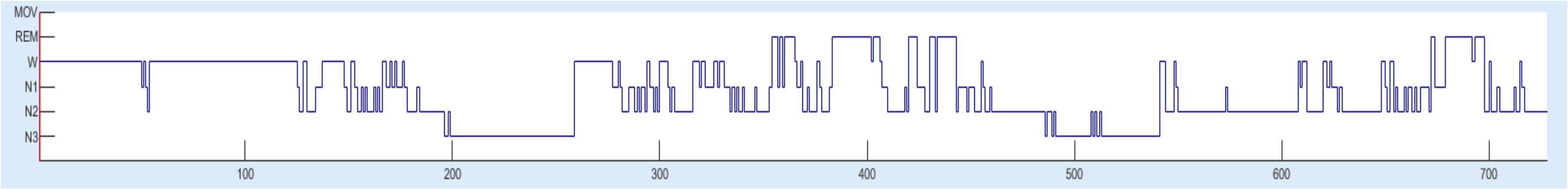




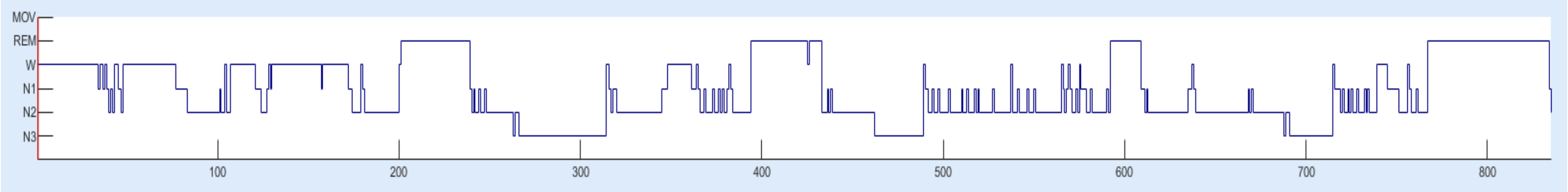
睡眠品質提升

- Patients with depressive or anxiety disorder.
- It shows objectively sleep quality enhancement after 4-week Neurofeedback training.

Before NFT, SE 72.9%, SD 24.5 min

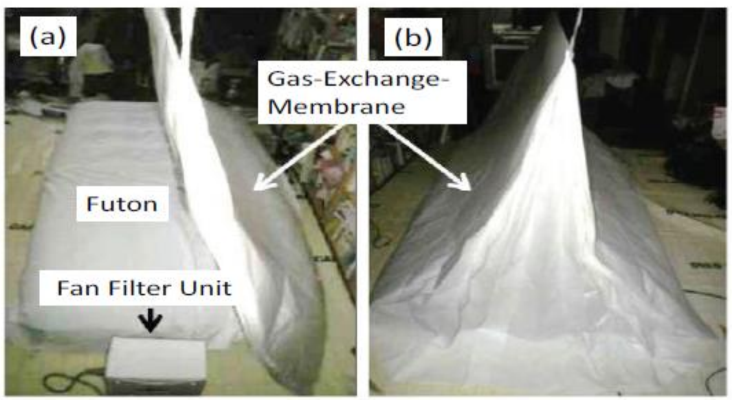


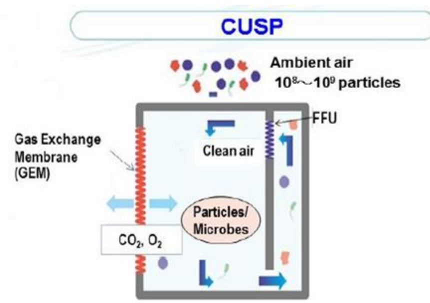
After NFT, SE 81%, SD 16.5 min

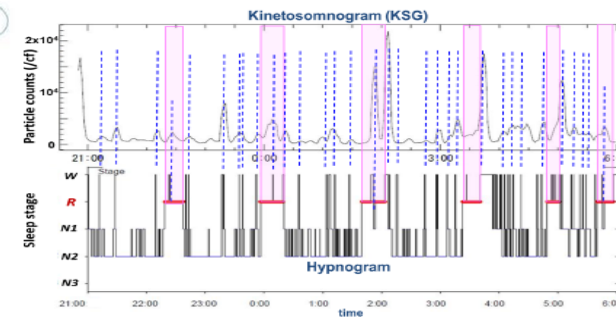


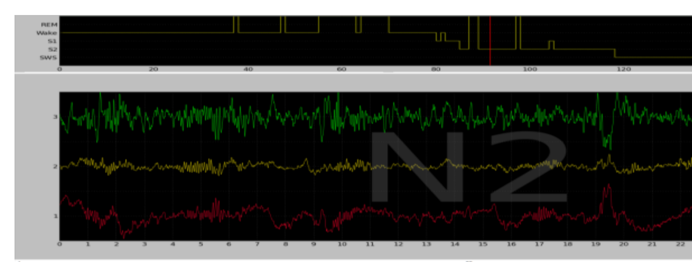
國際合作-睡眠環境改善與睡眠品質提升

- 北海道大學電子所石橋晃教授至成大醫資所與AI中心短期研究
- 結合Clean Unit System Platform (Hokkaido)與睡眠感測技術(NCKU)提升睡眠品質









跨領域醫學資訊人才培育

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智慧型醫學資訊系統實作


THANK YOU!