Brain Computer Interface (BCI) Based Smart Alarm and Sleep Classification

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Need
- About 70 Million Americans suffer from chronic sleep problems¹
- Sleep is a dynamic neurophysiological process characterized by sleep stages (REM, N1, N2, N3)² and wrist-based assessment inconsistent accuracy
- Waking in light sleep results in: ↑wakeup feeling³ and ↑cognitive function⁴

Project Objective:
Develop a near-real time BCI system that can determine sleep architecture (sleep stages throughout the night) and identify least disruptive wakeup time

Solution

BCI Smart Alarm and Sleep Classification:
- Continuous Near-Real-Time Processing
- Extraction of Frequency Based Features⁶
- Machine Learning Model Trained by Clinical Data⁶
- Time and Sleep Stage Dependent Alarm

Alarm Activation Signal (on/off) with Light/Sound Options

Impact and Next Steps
- Avoiding disruption of REM and deep (N3) sleep:
  ↑learning, ↑memory, ↑mood, ↑sleep inertia
- Accurate at-home sleep assessment with meaningful feedback:
  ↑public health, ↑workplace productivity, further sleep/health monitoring innovations

Reference:
² Miller et al. Chapter 4 - Methodology for the Assessment of Sleep, In Sleep and Affect, Elsevier Inc., 2015.
⁶ Fraiwan et al. Automated sleep stage identification system based on time–frequency analysis of a single EEG channel and random forest classifier. Computer Methods and Programs in Biomedicine, 2011.

Simulation Approach: 8-9 hours of chronological EEG data progressed in a loop

Testing
Requirement 1: 78.1 ± 0.2 % overall agreement > 75% compared to expert analysis⁵

Requirement 2: Alarm activation must (and does) occur within user-defined wakeup time window and during stages N1 or N2. Processing Time: 0.46 ± 0.03 seconds / epoch.