Real Time Sleep Detection System Using
New Statistical Features of the Single EEG Channel

Khalid Ali Aboalayon and Miad Faezipour
Departments of Computer Science and Engineering and Biomedical Engineering
University of Bridgeport, Bridgeport, CT

Abstract

Sleep specialists often conduct manual sleep stage scoring by visually inspecting the patient’s neurophysiological signals collected at sleep labs. This is, generally, a very difficult, tedious and time-consuming task. The limitations of manual sleep stage scoring have elevated the demand for developing Automatic Sleep Stage Classification (ASSC) systems. Sleep stage classification refers to identifying the various stages of sleep and is a critical step in an effort to assist physicians in the diagnosis and treatment of related sleep disorders. Many of the prior and current related studies use multiple EEG channels, and are based on 30s or 20s epoch lengths which affect the feasibility and speed of ASSC for real-time applications. Thus, the aim of this work is to present a novel and efficient real-time technique that can be implemented in an embedded hardware device to identify sleep stages using new statistical features applied to 10 s epochs of single-channel EEG signals. First, we run our algorithm off line using the PhysioNet Sleep European Data Format (EDF) Database to classify six sleep stages. The proposed methodology achieves excellent performance and works fast in real time in an efficient way using Neurosky Mindwave headset that gathers the user’s brain waves.

Proposed Method

One-channel EEG signals. First, we run our algorithm off line using the EDF Database to classify six sleep stages. The proposed methodology achieves excellent performance and works fast in real time in an efficient way using Neurosky Mindwave headset that gathers the user’s brain waves.

Significance

Sleep is the primary function of the brain and plays an essential role in an individual’s performance, learning ability and physical movement. Sleep is a reversible state in which the eyes are closed and several nervous system centers are inactive. Hence, sleep renders the individual either partially or completely unconscious and makes the brain a less complicated network. Humans spend around one-third of their lives sleeping and conditions such as insomnia and Obstructive Sleep Apnea (OSA) are frequent and can severely affect physical health.

New Feature Extraction

Because EEG is considered a non-stationary signal, and unlike stationary signals, has no specific patterns, the signal was segmented in the time domain into sub-windows to apply the first feature, Maximum-Minimum (MM) distance. The second feature, which determines the energy and speed of the EEG signal, is EnergySis. The assumption is that the number of samples (or length) of a sub-window is considered to be a power of 10, that should start from 100. This number is also used as the wavelength of the EEG waveform. In a generalized form, yielding the actual execution time of the algorithm.

Statistics

- 3.5% MMD
- 33% Inomnia
- 20% Sleep apnea
- 1% Sleeplessness
- 1% Epilepsy
- 65,000+ crashes, 500+ fatalities
- 7,000+ injuries
- $150 M lifetime medical costs

Statistics

- 3.5% MMD
- 33% Inomnia
- 20% Sleep apnea
- 1% Sleeplessness
- 1% Epilepsy
- 65,000+ crashes, 500+ fatalities
- 7,000+ injuries
- $150 M lifetime medical costs

Real Time System Results

- 3.5% MMD
- 33% Inomnia
- 20% Sleep apnea
- 1% Sleeplessness
- 1% Epilepsy
- 65,000+ crashes, 500+ fatalities
- 7,000+ injuries
- $150 M lifetime medical costs

Real Time System Results

- 3.5% MMD
- 33% Inomnia
- 20% Sleep apnea
- 1% Sleeplessness
- 1% Epilepsy
- 65,000+ crashes, 500+ fatalities
- 7,000+ injuries
- $150 M lifetime medical costs

Algorithm Time Complexity

Efficiency: 10 sec

Future Work and Conclusion

The new, simple statistical features developed in this work, called EnergySis and Maximum-Minimum Distance, provided an effective approach for analyzing the 10 s EEG signal capability for measuring and identifying brain activity states [1]. The use of 10 s epoch lengths is beneficial for real-time applications. Since the MindWave device and most smart phone devices integrate with applications. Therefore, our simpler, quicker and more feasible scheme makes our approach attractive for easy implementation and can be used to identify certain patterns such as fatigue, drowsiness and/or various sleep disorders (e.g., sleep apnea) in real-time.