Sleep Spindle Detection in EEG Signals combining HMMs and SVMs

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Abstract. In this paper we present a combined SVM-HMM sleep spindle detection scheme. The proposed scheme takes advantage of the information provided from each of the two prediction models in decision level, in order to provide refined and more accurate spindle detection results. The experimental results showed that the proposed combined scheme achieved an overall detection performance of 90.28%, increasing the best-performing SVM-based model by 2% in terms of absolute performance.

Keywords: sleep spindles, EEG, support vector machines, hidden Markov models.

1 Introduction

Over the last decades sleep medicine is studying sleep for the purpose of sleep disorders treatment. Electroencephalographic (EEG), eye movement (EOG) and electromyographic (EMG) signals of the subject are recorded throughout the sleep cycle. The analysis of those signals and the detection of specific patterns offers information related to sleep disorders. One such pattern is the sleep spindle.

Sleep spindles are characteristic transient oscillations that appear on the EEG during non-rapid eye movement (non-REM) sleep. Sleep spindles, also referred to as "sigma bands" or "sigma waves", may represent periods where the brain is inhibiting processing to keep the sleeper in a tranquil state. Along with K-complexes they are characteristic indicators of the onset of stage 2 sleep [1]. They are characterized by progressively increasing, then gradually decreasing waveforms, are affected by medication, aging and brain pathology and may be involved in learning processes [2]. Sleep spindles are important for the classification of the NREM sleep and the evaluation of the degree of arousal.

The amount and the distribution of the sleep spindles is essential for describing the morphology of the sleep EEG, thus the assessment of the distribution of sleep spindles over a whole sleep cycle is needed [3]. The low amplitude of some spindles,

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