Abstract

Tytuł angielski: Methods for EEG signal analysis amied at sleep apnea detection

Sleep apnea is one of the most common breathing disorders during sleep, characterized by repeated shortening or complete cessation of breathing. This disorder is associated with sleep fragmentation and has a significant impact on the well-being and health of people who experience it. Polysomnography is the gold standard for detecting sleep disorders. During polysomnography many signals are recorded, including an electroencephalogram (EEG). Research proposed in this dissertation concerns the analysis of a single-channel EEG signal in order to detect epochs of normal breathing and sleep apnea (binary classification) and its type: obstructive (OSA) or central (CSA) (three-label classification). The aim of the study was to propose an overnight single-channel EEG signal processing procedure to maximize the accuracy of both automatic classification between sleep apnea and normal breathing epochs, and the types of apnea.

The analysis of the EEG signal was performed by applying selected methods at each stage of signal processing: pre-processing, extraction and selection of features, and classification. As the best pre-processing methods were chosen: removal of saturation and excessive amplitudes, low-pass filtering limiting the frequency band to 45 Hz, removing the trend line and standardization of the EEG signal. Feature extraction were made by decomposing the signal into components using one-step methods: band-pass filtering (BPF), discrete transformation wavelet (DWT), empirical decomposition (EMD) and variational decomposition (VMD) and two-stage methods: Hilbert-Huang transform (HHT), DWT + HT and VMD + HT, for which 9 scalar features were calculated: skewness, median kurtosis, Hjorth parameters (activity, the proportion of activity to the sum of the activities of all signals, mobility, complexity), Shanon's entropy and the maximum amplitude, which resulted in feature vectors varying from 45 to 351 features, which together gave a total of 873 features. The ReliefF algorithm were chosen as the best feature selection method, which was used for each feature set, and then the selected features were combined to obtain a comprehensive set of 520 elements. Subsequently, features were re-selected from this overall set, which resulted in a reduction of the number of features to 387 (66.4% from HHT, 14 99% from DWT + HT).

The obtained feature vector was used to study and optimize the following classifiers: k-nearest neighbors (k-NN), support vector machines (SVM) and feedforward artificial neural networks (ANN). The accuracy of classifiers was assessed by applying 32-fold cross-

validation. Among the tested classifiers, k-NN and ANN enabled a flawless (100% accuracy) differentiation between the class of normal breathing and apnea, and SVM with an accuracy of 99,53%. The accuracy of the three-label classification was comparable for each of the classifiers and was above 82% (83,26% for SVM). The average sensitivity and precision of three-label classification for all classifiers was between 73% and 75%. Achieving 100% accuracy in the recognition of EEG epochs related to sleep apnea means that the proposed signal processing procedure can be used in the automatic support of medical diagnostics.

Keywords: data analysis, electroencephalography, sleep apnea, biomedical signal processing, features extraction and selection methods, machine learning, automatic medical decision support.

1.07.2021r. Monika Prucnal