

Sleep Apnea Detection Using Pulse Photoplethysmography

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Aim: Obstructive sleep apnea (OSA) often remains undiagnosed. Therefore, this study investigates the use of pulse photoplethysmography (PPG) for the detection of sleep apnea and its added value to oxygen saturation (SpO_2).

Methods: A dataset of 102 subjects, suspected of having OSA was recorded. 70 subjects were used for training, 32 for testing. Five PPG time series which are modulated by respiration were extracted: the pulse rate, amplitude and width variability (PRV, PAV and PWV), the slope transit time (STT) and the pulse upslope. The standard deviation (SD), slope, mean, minimum and maximum were computed over 10 second segments. For each annotated apnea, the segment with the lowest mean PAV, representing the apneic arousal, was selected for training the classifier. Moreover, an equal amount of non-apneic training segments per subject was added. Feature selection was performed using the minimal redundancy maximal relevance algorithm combined with a backwards wrapper. Classification was performed using fixed-size least squares support vector machines. The obtained model was applied to the full-night recordings and compared, using 1-minute segment classification performance, with an SpO_2 -based apnea detector based on desaturation severity and periodicity.

Results: 9 PPG features were selected: mean, slope and SD of the PRV, mean PAV, PWV slope, STT slope and SD and the minimum and maximum upslope. PPG-based classification achieved an averaged test set area under the ROC curve (AUC) of 70.4%, whereas, the SpO_2 -based classification achieved 86.5%. Both classifier outputs were combined in a multimodal classifier, which yielded an AUC of 87.0%, see Table 1. This study was performed on full-night recordings, including wake segments and both hypopneas and apneas. If only obstructive apneas were considered, the PPG-based classifier achieved an AUC of 78.1%. These results suggest that PPG parameters could be used for detecting OSA. Their added value is, however, limited if SpO_2 is available.

Table 1: Test set results of 1-min apnea classification

	Acc	Se	Sp	AUC
PPG	69.6%	56.4%	72.9%	70.4%
SpO_2	83.8%	73.7%	86.4%	86.5%
Combined	84.1%	71.9%	87.0%	87.0%