Unsupervised Artefact Detection in Ballistocardiography in Patients with Sleep Apnea

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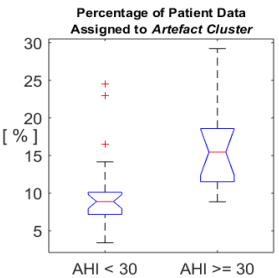
Aim: Ballistocardiography (BCG) is an unobtrusive measurement of the body's recoil caused by cardiovascular pulsation. It is prone to artefacts due to posture changes and movements. The aim is to identify these artefacts while not relying on visual scoring or information from other sensors. Therefore, an unsupervised approach is developed.

Methods: A pressure sensor on a hospital bed mattress acquired sleep data of 38 patients. Appropriate filtering of the pressure signal generates the respiration signal and BCG. First, discrete wavelet transforms were applied on all three signals to capture time-frequency information. Time-domain features were derived on the transformed and non-transformed signals. Highly correlated features were eliminated and 2000 training points were selected from 25 patients with Apnea–Hypopnea Index (AHI)<30 by k-medoids clustering. Next, unsupervised feature selection on the remaining 142 features was performed by Robust Spectral Learning (RSFS). The parameters of RSFS, number of features and clusters were optimized by a grid search and running the K-means algorithm. The silhouette score was then used to evaluate the performance of each iteration. Afterwards, data of all 38 patients were associated to the optimal clusters. Differences between features and clusters were evaluated using the Mann-Whitney U test with $p<0.05$.

Results: The highest silhouette score was 0.84 for two clusters with three features. These feature values in both training clusters were significantly different ($z=-31.90$, $z=-36.94$, $z=-37.20$). Cluster sizes of patients with AHI<30 were significantly different than patients with AHI≥30 ($z=-3.078$, Figure).



Conclusion: Results suggest that one cluster contains most of the artefacts as indicated by the distribution of its features. As expected, the cluster size increases for patients with more apneic arousals as these often distort the pressure signal. Therefore, this approach is potentially capable of identifying artefacts. Further analysis is needed to optimize the identification and the characterization of different artefacts.