An Improved ECG-Derived Respiration Method using Kernel Principal Component Analysis

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Deriving a respiratory signal from single lead ECGs has challenged many researchers. Recent studies showed that principal component analysis (PCA) generates better ECG-derived respiratory signals (EDR) than many other techniques. Assuming that respiration causes variations in the QRS morphology, the direction of maximal variance using a linear transformation is computed from a matrix that contains all QRS complexes. An EDR signal is generated by the coefficients of the first principal component. This EDR technique is improved by extending linear PCA to kernel PCA (kPCA). Kernel PCA has the advantage over PCA of also taking nonlinearities of the data into account when maximising the variance. As there is no proof that respiration linearly varies the ECG recordings, a more accurate EDR signal is expected with kPCA. When applying kPCA, the data is first nonlinearly mapped into a higher dimensional space, in which PCA is carried out. Reconstruction of the input data from that higher dimensional space generates an improved EDR signal. To evaluate the performance of kPCA as a tool for EDR, the freely available Fantasia database from PhysioNet was used. From each recording (n=40), we selected 5 minutes and generated two EDR signals by applying PCA and kPCA. The correlation coefficients and magnitude squared coherence coefficients at respiratory frequency of the EDR signals compared to the reference respiratory signal were computed to quantify the performance of both methods. Correlation values of (0.630 ± 0.189, 0.675 ± 0.163) and coherence values of (0.819 ± 0.229, 0.894 ± 0.139) were obtained for PCA and KPCA respectively. The Wilcoxon signed rank test showed p-values of 0.0257 and 0.0030 for respectively the correlation and coherence coefficients, indicating statistically significantly higher coefficients for kPCA than for PCA. To conclude, kPCA proves to outperform PCA in the extraction of a respiratory signal from single lead ECGs.