PCA-based Noise Reduction in Ambulatory ECGs

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Ambulatory cardiac monitors have experienced an increment in autonomy and functionality with the improvement of low-power microelectronics. They are able to perform some signal processing and data interpretation. However, motion artifacts can mask the ECG signal. This paper, investigates a denoising algorithm based on PCA due to its relatively low computational complexity. A database was generated by combining clean 8-lead ECG with noise signals containing motion artifacts at different levels of activity. SNR values ranging from 10 to -10 dB were considered. 8-channel PCA was applied and then inverted after selecting a subset of principal components (PC). For evaluating signal improvement, the correlation coefficient between the noise-free signal and the output after PCA filtering was computed. In addition, SNR before and after PCA was estimated. Firstly, PC that best matched the ECG was identified in function of the signal SNR. Above 0dB, the PC corresponding to highest variance gave best performance, below 0dB the best PC was the second or the third with highest variance. The number of PCs in function of the SNR was then investigated. It was observed that when SNR decreased, PCA performed better when retaining less number of PCs (4 PCs for a SNR=10dB down to 1 PC for SNR=-10dB). Reducing the number of input ECG leads did not yield to a significant difference when it was reduced from eight (median SNR improvement of 2.60 dB (MAD=2.35)) down to two (median SNR improvement of 2.06 (MAD=1.95)). Based on these results, a method for identifying the subset of PC that matches the ECG was proposed as function of input SNR and number of channels. This method gave an SNR improvement of 2.5dB-3.2dB depending input SNR.