Radial Basis Function Networks Applied to QRST Cancellation in Atrial Fibrillation Recordings

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Atrial fibrillation (AF) is the most common type of human cardiac arrhythmia. Due to the much higher amplitude of the electrical ventricular activity (VA) on the surface ECG, cancellation of the ventricular involvement is crucial in the study of AF from the ECG. Two approaches are generally used to perform this task: source separation algorithms and average template subtraction. Source separation algorithms try to find uncorrelated components using a principal component analysis (PCA), or to find independent components in an instantaneous linear mixture using an independent component analysis (ICA). On the other hand, the methods based on average beat subtraction (ABS) obtain a median template that is then used to subtract the VA. In this contribution, a QRST cancellation method using a radial basis function (RBF) network is proposed. This RBF network has been developed like a hierarchically layered structure. It starts with a small number of RBFs and then adds new RBFs if the approximation error is larger than some predetermined threshold and there is no existing RBF that can efficiently represent the current input. The adaptation strategy for the weight matrix of the RBF network is developed using the Lyapunov approach. This proposed approximation strategy guarantees uniform ultimate boundedness of the approximation error, which is proved using the second Lyapunov method. The cancellation system has been developed using Gaussian RBF (GRBF) and the outcomes compared with ICA-based methods and ABS techniques using cross correlation (CC), mean square error (MSE), ventricular depolarization reduction (VDR) and similarity the similarity index(S). Both real and synthetic signals have been used to reach a total amount of 400 recordings in the study. Average Results for the RBF method applied to the synthetic signals are (mean$\pm$std) CC=0.95$\pm$0.021 and MSE=0.356$\pm$0.102 in contrast to the previous published methods that, for the best case, yielded CC=0.86$\pm$0.031 and MSE=0.491$\pm$0.213. For real signals VDR and S obtained for RBF were VDR=7.01$\pm$2.23 and S=99,39%$\pm$0.33, and the classical techniques provided, in the best case, VDR=4.23$\pm$3.02 and S=92,23%$\pm$0.44. The results prove that RBF based methods are able to obtain a very accurate reduction of VA, thus providing high quality atrial activity extraction in AF recordings.