Deep-Learning Premature Ventricular Contraction Localization Using Gaussian Based Predicted Data

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Aims: Detection of cardiac arrhythmias is still an ongoing challenge. Most of the standard methods for premature ventricular contraction (PVC) detection are based on the extraction of the ECG features and applying specific decision rules. Even though mentioned methods' results are satisfying, the decision process is time-consuming and requires cooperation with highly qualified medical experts. We introduce a deep-learning-based method for PVC localization. Our method uses Gaussian function-based predicted network output and has no above limitations.

Methods: To localize PVCs, a convolutional neural network (CNN) was created. Positions of the PVCs are predicted by the model from raw 12-lead ECGs (China Physiological Signal Challenge 2018). The predicted network output consisted of two parts. The first one was a global classification label: Normal/PVC. The second one included a time series where the non-zero values correspond to the PVC positions. To improve the efficiency of the training process, the transition between the non-zero and zero areas in the predicted output was smoothed by introducing a Gaussian function. The parameters of the function were optimized to meet the parameters of PVCs. When applied to new ECGs, the output signal (time series including gaussian prediction) is processed by a robust peak detector with Bayesian optimization of threshold, minimal distance, and peak prominence. Positions of detected peaks correspond with desired PVC positions.

Results: Altogether, 1571 signals were used (653 PVC, 918 Normal) and were split into training and testing datasets in a 4:1 ratio. The model with the most successful setting reached the F1-score of 0.88. Compared to the standard method, the presented algorithm allows not only the global classification of the signal (Normal/PVC) but also the accurate detection of PVC positions.

Conclusion: The presented approach combines original predicted output data with the state-of-the-art deep-learning model. The results are comparable with recently reported methods.