Deep-Learning Premature Contraction Localization in 12-lead ECG from Whole Signal Annotations

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Aims: Premature ventricular contraction (PVC) is one of the commonly diagnosed arrhythmias. Since common diagnostics approaches are time-consuming and arrhythmia-type sensitive, deep-learning methods are state-of-the-art for their detection accuracy, which can even surpass qualified medical experts. However, PVCs localization via common deep-learning approaches requires large training set including detailed PVCs annotation. Our model has no such limitation. It localizes PVCs based on information extracted from the whole signal annotation.

Methods: Modified 1D convolutional neural network was trained from the whole ECG labels. To enable PVCs localization with no available labels for single PVCs, Multiple Instance Learning framework was applied. By processing input ECG via several convolutional and pooling layers, subsampled feature signal (position likelihood) of a variable length (bag of instances) is obtained and is projected to a single output label by global average pooling. The feature signal indicates, whether this part of ECG contributed positively or negatively to final prediction. Thus, high feature values correspond to PVC positions (see figure). The maps of PVC likelihood are processed detection to get PVC locations.

Results: Our method was tested on database containing 1590 ECGs, including 672 signals with PVCs. According to visual assessment on 305 test signals, F1-score reaches 0.89. Main advantage of our method is it's applicability on diagnostics of various types of cardiac abnormalities.

Conclusion: Proposed deep-learning method for PVCs localization achieves promising results while being trained from the whole signal annotations instead of positional labels.