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A novel method based on convolutional neural networks for deriving standard 12-lead ECG from serial 3-lead

Key words: Convolutional neural networks (CNNs);
Electrocardiogram (ECG) synthesis; E-health

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Motivations

1. Electrocardiogram (ECG) is one of the most important noninvasive diagnostic tools for heart disease and one of the most commonly performed cardiology tests.
2. With the rapidly increasing incidence of heart disease worldwide, more convenient and accurate ECG monitoring for pre-hospital care is required.
3. The accuracy and real-time performance of traditional methods need to be improved.

Main ideas

1. Since convolutional neural networks (CNNs) learn the feature from the training data directly, it can avoid loss of effective features and enhance accuracy.
2. Considering 1D-ECG to 2D-ECG conversion, we refer to the gradient-based method on image/shape reconstruction and the traditional matrix reconstruction method based on slipping insertion.
3. Using a CNN-based model to reconstruct the 12-lead ECG signal from the 3-lead ECG.

Methods

1. Discrete wavelet transform (DWT) was used to denoise the original ECG signal, and 1D-ECG was transformed to 2D-ECG as the input data.
2. ECG signal was segmented into heartbeat signals.
3. A 9-layer CNNs model was built for reconstruction the 12-lead ECG.

Major results

1. CNN-based method can reconstruct the signal better.

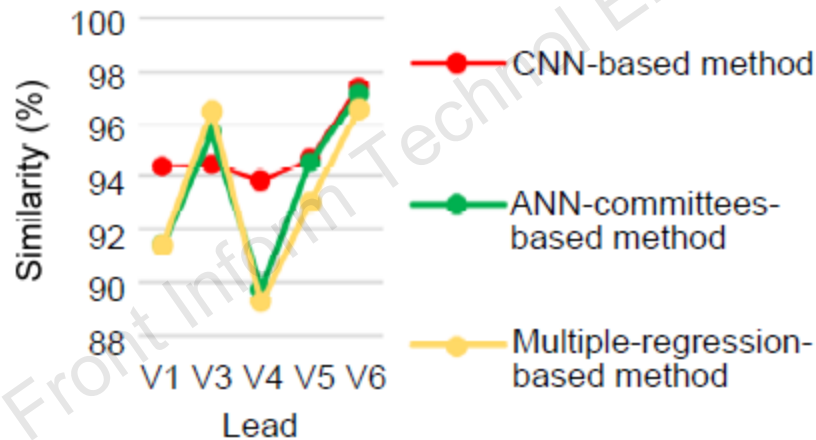


Fig. 9 Line chart of similarity obtained using three methods

Major results (Cont'd)

2. CNN-based model spent less running time than the ANN-committees-based model.

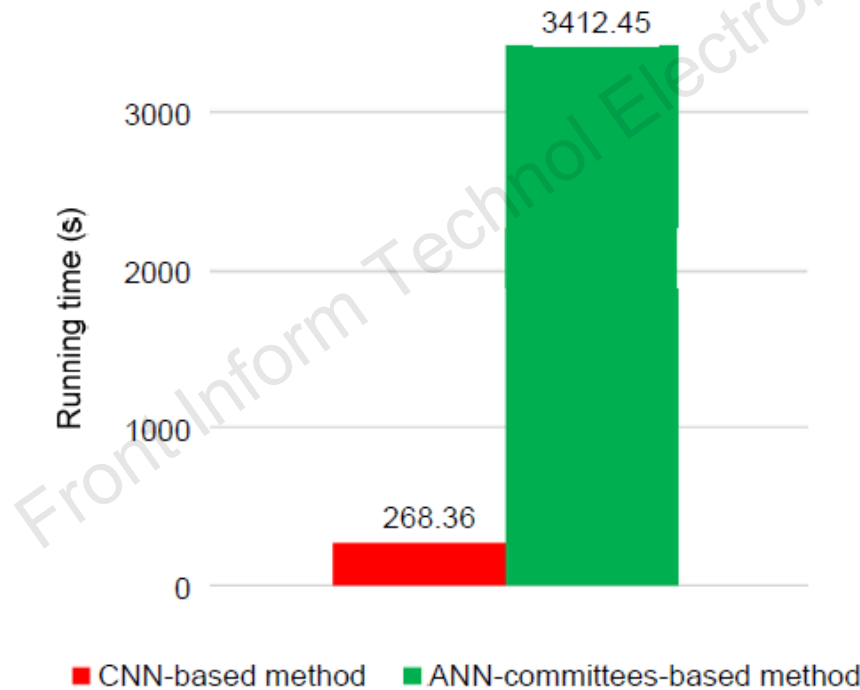


Fig. 12 Running time of the proposed CNN-based method and the ANN-committees-based method

Conclusions

1. The reduction of running time during synthesis is important, considering the large amount of signal and the real time requests.
2. Compared to linear regression and ANN, our method has not only better similarity between the reconstructed and original ECGs, but also less time consumption.