

Combining Singular Spectrum Analysis and Neural Networks for Atrial Fibrillation Classification in ECG Signals

Aim: In methods of using deep learning for atrial fibrillation (AF) classification, ECG signals are conventionally transformed into spectrograms to feed into the network. However, spectrograms may contain irrelevant or redundant information that negatively impacts classification accuracy. To overcome this, we propose a method that uses two-dimensional singular spectrum analysis (SSA) to effectively extract features and reduce redundancy in signals. Traditional SSA techniques require empirical selection of components, which may not always be optimal for classification of complex ECG signals. Therefore, we introduce a data-driven method for selecting SSA components to precisely extract useful information for AF classification.

Methods: Our proposed model consists of an automatical SSA component selection block (SCSB) and a CNN classification block (CCB). The SCSB represents the ECG signal's spectrograms as the sum of SSA components with different characteristics. Then, we construct a learnable component selection layer that automatically decides which components are important for AF classification through training. The CCB extracts features from the filtered spectrograms using convolutional filters that slide over the filtered spectrograms, identifying patterns and structures at various scales to accurately classify AF.

Results: Compared to the method with conventional SSA components selection method, our proposed method demonstrates a significant improvement in the accuracy of AF classification by 13.017%, and a slight improvement in the F1 score by 0.003%. Furthermore, compared to other state-of-the-art algorithms, our method also shows varying degrees of improvement in the performance of AF classification.

Conclusion: Our study proposes a novel approach for AF classification using a combined neural network model that integrates two blocks: SCSB and CCB. By automatically selecting important SSA components through a learnable component selection layer, our proposed model effectively extracts features and reduces redundancy in ECG signals, resulting in improved classification accuracy.