Ensemble Deep Convolutional Recurrent Neural Networks for Automated Diagnosis of Cardiac Abnormalities in 12-Lead ECGs

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Aims: In biosignal classification tasks, deep learning has proven to overcome classic methods based on feature extraction and machine learning, possibly due to its ability to learns inherent features of each class while eliminating the need to extract ad-hoc features. As part of the PhysioNet/Computing in Cardiology Challenge 2020, this work focuses on the classification of 12-lead electrocardiogram (ECG) signals into 9 different cardiac abnormalities, most of which are arrhythmia.

Methods: Our approach includes a 2-stage deep learning ensemble model based on convolutional and recurrent neural networks. The first layer of the ensemble comprises of three sub-networks, namely 1D-residual network, naive inception-like residual network, and plain sequential convolutional neural network (CNN), all of which were coupled with a long short-term memory (LSTM) network to extract effective temporal features and inherently model time dependencies from short segments of 6 seconds. For the second layer, we deploy a bidirectional-LSTM, which serves as a meta-learner taking as input the prediction probabilities obtained from the first layer models over the full length of the signal. The use of the second recurrent network as a meta-learner is advantageous in enhancing the performance while allowing also the classification of signals of variable length.

Results: The challenge dataset consisted of 6,877 multi-lead ECG recordings between 6 s and 60 s in length with a sampling rate of 500 Hz. Our ensemble obtained an average F_β measure of 0.81 on the training set (5-fold cross-validation), and 0.773 on the hidden testset during the unofficial phase of the challenge.

Conclusion: Our classification results demonstrate that a stacked ensemble deep learning approach can potentially identify a wide variety of distinct arrhythmia from 12-lead ECGs that could support a robust patient diagnosis.