Multi-label Classification of 12-lead ECG Using Deep Transfer Learning on Spectrograms by Continuous Wavelet Transform

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Aims: We considered a multi-label classification task of 12-lead ECG signals for pathological identification, using the spectrograms from continuous wavelet transform (CWT) to characterize ECGs.

Methods: We were provided with 6,877 12-lead ECG signals by the PhysioNet/CinC 2020 Challenge. After a fifth-order Butterworth filter with the passband of $0.5 - 50$ Hz, the signals were segmented into a fixed number of 3000-ms segments. Morlet-kernel based CWT was applied to each segment, resulting in 12-channel spectrograms, which were fed into a 50-layer ResNet model pre-trained on ImageNet, where the first layer was adapted for the 12-channel input, and a sigmoid layer was added to produce a probabilistic output. A weighted binary cross-entropy loss considering the recall-precision weighting $\beta = 2$, as well as the imbalanced class problem was minimized using stochastic gradient descent. Finally, the maximal predicted probability of each class across all segments of each ECG was taken as the prediction.

Results: We adopted 11 signal segments for each signal. After 20 epochs of training, the 5-fold cross-validation reported $F_\beta = 0.745$ and $G_\beta = 0.550$, and the testing score from the PhysioNet/CinC 2020 Challenge (team name: ECGLearner) reported $F_\beta = 0.744$ and $G_\beta = 0.512$.

Conclusions: The results suggested that deep transfer learning could be useful to identify patterns in CWT spectrograms of 12-lead ECGs.