Wide and Deep Transformer Neural Networks for Multi-Lead ECG Classification

Gregory Boverman[1], Annamalai Natarajan[1], Yale Chang[1], Corneliu Antonescu[2] and Jonathan Rubin[1]
[1]Philips Research North America, Cambridge, USA
[2]Banner-University Medical Center, Phoenix USA

Background:

Cardiac abnormalities are leading causes of death and early diagnosis allows providing timely intervention. The goal of 2021 PhysioNet/CinC Challenge is to develop algorithms to diagnose multiple cardiac abnormalities using varying numbers of ECG leads, namely 2, 3, 6 and 12-lead ECG signals respectively. In this work, we develop wide and deep transformer neural networks to predict 27 cardiac abnormalities from the above lead-sets.

Method:

Our network combines traditional hand-crafted (*wide*) ECG features together with (*deep*) features extracted directly from the raw ECG waveforms via a neural network. For encoding deep features, we first perform a series of convolution operations to learn an embedding of the raw waveform. Learned embeddings are then fed into a Transformer *encoder-only* architecture, which relies entirely on a parallelizable self-attention mechanism. A final set of fully connected layers combine both the 'wide' and 'deep' features to produce multi-label classifications of ECG findings. The average binary cross entropy over 27 classes was used as the loss function and overall AUROC is used as the validation metric for model selection and early stopping. We train separate models for 2, 3, 6 and 12 leads that differ only by the channel dimension of the very first convolution operation.

Results:

Results from a local 10-fold nested cross validation procedure results in a challenge metric of 0.543, 0.516, 0.522 and 0.488 for the four lead datasets respectively. We submitted a single entry to the challenge server using the team name **prna** that resulted in leaderboard scores of 0.571, 0.270, 0.531, and 0.520 corresponding to the four lead datasets respectively.

Discussion:

We have extended our winning entry to the 2020 PhysioNet/CinC challenge to handle multi-lead datasets of varying size. The reasons for the drop in performance for the 6-lead dataset on the challenge validation data will be further explored.