Cardiac Abnormalities Recognition in 12-lead ECG Using a Convolutional Network with Binary Units Training Technique

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Aims: Deep learning-based ECG interpretation has been proved as a successful alternative for time-consuming manual ECG scoring requiring highly qualified medical experts. In this entry, we present 12-lead ECG classification into nine categories, including normal sinus rhythm and eight different cardiac arrhythmias.

Methods: A Convolution Neural Network (CNN) based on ResNet architecture was used for data classification. Instead of common 2D convolution for images, 1D convolution was used in ResNet network. Global max-pooling was applied before the last layers of the network to enable the processing of variable length ECGs. Zero-padding was used to create mini-batches of signals of equal size. The zero-padded parts were then removed before the max-pooling procedure. The final layer utilizes Binary Units Training Technique (BUTT), which consists of nine fully connected binary classifiers. BUTT allows the assignment of each signal to any mixture of categories. To reduce the negative effect of data imbalance, the cross-entropy loss was weighted by the number of positive and negative instances in particular categories. In order to improve model performance, raw output scores were thresholded with category-specific thresholds optimized on the validation set. Final prediction was achieved with an average prediction of an ensemble of 11 models, each trained on randomly sampled 80 % of the training data.

Results: In the official challenge entry, we have achieved 0.737 for a geometric mean of F2 measure and G2 measure (official challenge metric). For cross-validation on the training dataset, this metric reached 0.764.

Conclusion: Our algorithm based on modified ResNet CNN with BUTT as specialized last layer, automatically identifies the cardiac abnormalities in 12-lead ECG recordings. In an early phase challenge entry, our team (BUTTeam) reached first place with 0.737 of challenge metric.