Hybrid Arrhythmia Detection on Varying-Dimensional Electrocardiography: Combining Deep Neural Networks and Clinical Rules

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Aim: This study aims to develop robust and high-performance algorithms for the detection of cardiac arrhythmias from varying-dimensional electrocardiography (ECG), taking advantage of both deep neural networks and insights from clinical criterion.

Methods: 24 classes (equivalent classes are counted one) of ECGs are divided into two categories. For each class (totally 5) in the category with clear, easy-to-describe clinical diagnostic criterion, descriptors are manually designed to make binary classification.

For the rest 19 classes with subtle morphological and spectral characteristics, convolutional neural networks (CNNs) are adopted for multi-label classification. Network inputs are resampled (500Hz) and bandpassed ECGs, which are further normalized to fixed mean and variance. To make the networks capable of capturing features of different scopes, we use several branches of sequential convolutional blocks, each with different receptive field via dilated convolutions. Feature maps from these branches are concatenated and fed into the classifying linear layer(s). Considering ECGs' varying dimensionality, convolutions are grouped with group number equaling the number of ECG leads, which we name "lead-wise convolutions". To accelerate convergence and training speed, activations and grouped normalizations are applied after convolutions. Adaptive thresholding is used to give final prediction. For training the CNNs, stratified split with train-test ratio of 8:2 is made on the entire dataset. Input ECGs are clipped or padded to ensure 10s length.

Predictions from CNNs and from manual descriptors are merged to give final judgements.

Results: In our (team name "Revenger") experiments, the best challenge metrics of our hybrid algorithm are 0.515, 0.486, 0.506, 0.480 on 12-lead, 6-lead, 3-lead, 2-lead on our left-out validation set; and 0.524, 0.430, 0.495, 0.484 on those of the official hidden test set respectively.

Conclusion: The combination of "lead-wise" branched CNNs and clinical rules offers a promising lightweight and robust solution to the problem of arrhythmia detection on varying-dimensional ECGs.