Classification of Cardiac Arrhythmias from 12-lead ECGs with a Convolutional Recurrent Neural Network

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**Aims:** Cardiac arrhythmias are typically diagnosed using a 12-lead electrocardiogram (ECG). ECG manual interpretation is time-consuming and requires specialized training. This study aimed to assess the use of a convolutional recurrent neural network for automatic classification of cardiac arrhythmias from 12-lead ECG.

**Methods:** A database of annotated 12-lead ECGs (n = 6,877) was provided by the PhysioNet Computing in Cardiology Challenge 2020. Each recording was annotated with one or more labels corresponding to 9 different cardiac rhythms (normal sinus rhythm; NSR, atrial fibrillation; AF, first-degree atrioventricular block; I-AVB, left and right bundle branch block; L/RBBB, premature atrial and ventricular complex; PA/PVC, ST segment depression and elevation; STD/E). The network architecture developed is illustrated in Figure 1. To help prevent overfitting during training, alongside five-fold cross validation, dynamic data augmentation was used at each epoch to alter the heart rate and amplitude of the ECG.

**Results:** Five-fold cross-validation yielded average F1, F2 and G2 scores of 0.80, 0.79 and 0.62 respectfully (F1 by class: AF 0.87; I-AVB 0.86; LBBB 0.83; NSR 0.77; PAC 0.67; PVC 0.80; RBBB 0.89; STD 0.78; STE 0.32). In the unofficial phase of the challenge, the model yielded average F1, F2 and G2 scores of 0.74, 0.54 and 0.63 respectfully.

**Conclusion:** The results show that our model can successfully detect many different cardiac arrhythmias in varying length 12-lead ECGs.

![Figure 1. Model architecture. Seven feature extraction modules (C: 1D convolution, B: batch normalization, R: relu, M: maxpool, D: dropout), a 1D average pool layer and a recurrent classification module (F: flatten, L: long short term memory, FC: fully connected, S:softmax).](image-url)