A Self-attention based Deep Learning Model for Arrythmia Classification from ECG Signals

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Introduction: Electrocardiograms (ECGs), a medical monitoring technology recording cardiac activity, are widely used for diagnosing cardiac arrhythmia. The diagnosis is based on the analysis of the deformation of the signal shapes due to irregular heart rates associated with heart diseases. Due to the infeasibility of manual examination of large volumes of ECG data, this paper aims to propose a deep-learning-based technique that uses a self-attention mechanism for ECG-based arrhythmia classification.

Methods: Twelve lead electrocardiograms (ECG) of length 10 sec from 45,152 individuals from Shaoxing People's Hospital (SPH) dataset from PhysioNet with four different types of arrhythmias i.e., atrial fibrillation (AFIB), supraventricular tachycardia (ST), sinus bradycardia (SB), and sinus rhythm (SR) were used. The sampling frequency utilized was 500 Hz. Median filtering was used to preprocess the ECG signals. For every 1 sec of ECG signal, the time-frequency (TF) scalogram was estimated, resulting in 10 TF scalograms for each ECG signal. The TF scalogram image was used as an input to a simple convolutional neural network (CNN) architecture along with the self-attention mechanism used for arrhythmia classification.

Results: The proposed model obtained a test accuracy of about 80.06% in ECG arrhythmia classification. For each of the four ECG classes (AFIB, SB, SR, and ST), the precision of 0.65, 0.91, 0.80, 0.71, recall of 0.43, 0.98, 0.76, 0.86, and F1-score of 0.52, 0.94, 0.79, 0.78 were obtained.

Conclusions: Our experimental results demonstrate the efficacy of the simple CNN model along with the self-attention mechanism in the automatic classification of arrhythmia types from ECG signals. This work will be extended to further improve the accuracy rate of the ECG-based arrhythmia classification system using advanced attention mechanisms (such as multi-head attention and cross-attention) across large scale datasets. Additionally, other ECG arrhythmia classes will also be considered for further study.