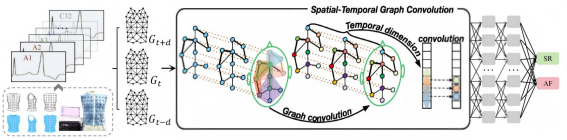
Detection of Paroxysmal Atrial Fibrillation from Sinus Rhythm Using 96-Lead Electrocardiography and Graph Neural Networks

Qingrong Wu, Xin Lian, Haiying Li, Yanhong Chen, Jian Wu

Tsinghua Shenzhen International Graduate School
Shenzhen, GD, CHN

Aims: Atrial fibrillation (AF) may occur asymptomatically and can be diagnosed only with electrocardiography (ECG) while the arrhythmia is present. This study aimed to propose a novel diagnostic approach based on 96-lead high-density body surface ECG, using deep learning to identify paroxysmal AF from sinus rhythm (SR) recordings and improve early detection accuracy.



Outline of the ST-GCN network.

Methods: A 96-lead high-density body surface ECG system with uniformly distributed electrodes was used to capture cardiac electrical activity at higher spatial resolution than conventional 12-lead ECG. A spatio-temporal graph convolutional network (ST-GCN) was developed to model the non-Euclidean structure of the signals. The 96 electrodes were represented as graph nodes, inter-electrode spatial distances as edges, and ECG signals as node features, enabling joint learning of spatial and temporal characteristics. Data were collected from The University of Hong Kong-Shenzhen Hospital. Patients with at least one documented AF episode were labeled AF-positive. The dataset was randomly divided into training, validation, and test sets at a ratio of 7:1:2. Model performance was assessed using area under the receiver operating characteristic curve (AUC), accuracy, sensitivity, and specificity.

Results: A total of 5,026 sinus rhythm 96-lead ECG recordings from 53 patients (27 with a confirmed history of AF, 26 without) were included. On the test set, the ST-GCN model achieved an accuracy of 82%, an AUC of 0.88, a sensitivity of 87%, and a specificity of 77%. To further improve performance, a graph attention mechanism was introduced, resulting in a spatio-temporal graph attention network (ST-GAT) that increased accuracy to 90%, AUC to 0.92, sensitivity to 97%, and specificity to 85%, outperforming reported results from existing large-scale 12-lead ECG studies despite the limited sample size.

Conclusions: Using high-density 96-lead ECG, the proposed ST-GAT model shows potential for improved detection of latent AF compared with conventional 12-lead methods.