A Transfer Learning Model -Based Patient-Specific ECG Lead Synthesis Algorithm

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Background: Diagnostic 12-lead Electrocardiogram (ECG) analysis is a cornerstone in clinical cardiology, offering essential insights into cardiovascular health. However, the complexity of attaching multiple electrodes for a comprehensive analysis can sometimes present a challenge. This study aims to address this challenge by developing a novel deep learning model that synthesizes ECG leads by combining global and patient-specific models, thereby further improving the accuracy of the synthesized leads.

Methods: We developed a deep learning model featuring an encoder-decoder structure, as depicted in Figure 1, tailored for ECG lead synthesis. This model processes inputs from four measured ECG leads (I, II, v2, v4) and generates outputs for four synthesized leads (v1, v3, v5, v6) using various sizes of one-dimensional convolutional layers. Initially, the model was trained with a comprehensive dataset of 3,000 ECGs provided by Mayo Clinic to establish a robust global synthesis framework. We then froze the trained model and incorporated a new trainable layer designed for adaptation to new patient-specific data. This adaptation process, facilitated by the model's ability to operate with compact data sizes, ensures its practical application at the point-of-care, enabling real-time adjustments to the model based on immediate patient data. We employed waveform cross-correlation (Rx) and Root-Mean-Square Error (RMSE) as our primary metrics to assess the accuracy of the synthesized leads compared to actual measurements.

Results: The global synthesized lead model's average Rx values for leads v1, v3, v5, and v6 were [0.94, 0.92, 0.95, 0.93]. The patient-specific model's average Rx values are [0.95, 0.94, 0.96, 0.95] respectively. The RMSE values for the same leads improved from [0.05, 0.07, 0.05, 0.05] to [0.03, 0.06, 0.04, 0.04] mV respectively.

Conclusions: This study demonstrates that the transfer learning patient-specific model enhances the accuracy of synthesized ECG leads, offering promising implications for the clinical application of reduced-lead ECG analysis.