Bidirectional 12-Lead Electrocardiogram and Electrogram Reconstruction Using a Cycle Generative Adversarial Network

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Cardiovascular disease (CVD) is the leading cause of death worldwide. The standard 12-lead electrocardiogram (ECG) is the benchmark for CVD diagnosis, yet it is currently impractical for continuous monitoring. Deep learning algorithms can derive cardiac information that is otherwise not easily recorded. This study (1) developed a CycleGAN architecture adapted to unidimensional biomedical signals (2) applied a Cycle Generative Adversarial Network (CycleGAN) framework to 3-lead electrograms (EGMs) and 12-lead ECGs and (3) synthesized the 12-lead ECG from 3-lead ECGs. The CycleGAN was trained using PhysioNet's PTB-XL database and generated EGMs, and a 1st order Butterworth filter was applied to the signals. The CycleGAN was adapted to generate synthetic biomedical signals in the absence of paired data, one-dimensional convolutions were implemented, and a Leaky Rectified Linear Unit (ReLU) function was added to the output layer. The CycleGAN accurately reconstructed the 12-lead ECG from a 3-lead ECG and 3-lead EGM at Pearson correlations of 0.99 and 0.96, respectively. The reverse reconstruction was performed to reduce irregularity search and electronically delineate the heart in cardiac ablation procedures, achieving a Pearson correlation of 0.99. The proposed framework outperformed previous state-of-the-art studies, indicating that bidirectional CycleGAN reconstruction of ECGs and EGMs can permit accurate diagnosis, early detection, and immediate treatment of deadly CVDs with minimal equipment necessary. Future investigations include reconstructing the 12-lead ECG from photoplethysmography (PPG) via a convenient finger clip, thus enabling real-time, continuous monitoring of cardiovascular activity in a three-dimensional plane.

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Third Award of $1,000