Comparing Time-Frequency and Time Domain ECG Data for Forecasting and Detection of Atrial Fibrillation

Njegos Ljusic, Bjørn-Jostein Singstad & Vimala Nunavath

University of South-Eastern Norway
Kongsberg, Norway

Introduction: Atrial fibrillation (AF), the most prevalent sustained cardiac arrhythmia, affects roughly 2% of the general population and is linked to stroke, heart failure, and higher mortality. AF may occur in brief episodes that are often missed on a standard resting 12-lead, 10-second electrocardiogram (ECG), necessitating longer recordings. However, these extended recordings are impractical for manual review by clinicians, creating a need for computerized, automated detection of atrial fibrillation.
Purpose: This study aims to extend state-of-the-art research based on the IRIDIA-AF database by addressing open questions about using both 2D spectrograms and 1D ECG window segments as inputs to convolutional neural network (CNN) models for AF prediction and detection.
Methodology: The IRIDIA-AF database contains 167 records from 152 patients with paroxysmal AF. Each record lasts 19 to 95 hours and is split into 24-hour files. To forecast and detect AF, 10- and 30-second 1D ECG windows and 2D spectrograms from leads I and II were generated. For AF forecasting, 355 pre-AF and normal case pairs (710 segments) were used, whereas AF detection employed 4500 AF and normal case pairs (9000 segments).
Results: As shown in Table 1, for forecasting tasks, models based on 2D spectrograms generally outperformed those using 1D raw ECG data, whereas for detection, the two approaches yielded comparable performance.

Table 1. Testset performance for atrial fibrillation detection and forecasting using waveform inputs (1D) and mel-spectrogram representations (2D)

Task	Dim.	Model	Window	AUROC
Forecasting	1D	Inception	10	0.86
	2D	CustResNet	10	0.97
Detection	1D	CustResNet	30	0.99
	2D	CustResNet	30	0.99

Conclusion: Although detection performance did not differ substantially between the 1D and 2D models, there was a marked difference in forecasting performance. The 2D model, in particular, achieved notably strong forecasting results, approaching the performance level of the detection models.