

Towards reconstruction of full 12-lead 10-second ECG from 2.5-second Cabrera-formated fragments

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Introduction: Recent work on digitizing 12-lead paper ECGs shows that automatic conversion to digital waveforms can be highly accurate. Nevertheless, the standard 12-lead, 10-second paper ECG printed in the commonly used Cabrera format typically displays only 2.5 seconds of each lead, except for lead II, which is present in its full 10-seconds length. Consequently, approximately only one quarter of the original ECG recording is actually recovered after digitization. Here, we introduce an approach for recovering missing segments of ECG signals from their digitized paper recordings.

Methods: We used the PTB-XL dataset to create a modified version that simulates a digitized paper ECG by selectively removing segments of the signal to replicate the Cabrera display format. We trained a convolutional neural network with a U-Net architecture to reconstruct the removed segments and recover the complete 12-lead ECG.

Results: The pairwise comparison between the reconstructed and original ECG signals resulted in a root mean squared error (RMSE) of $80 \mu\text{V}$ and a Pearson correlation coefficient of 0.90 when evaluated over all leads. Furthermore, the mean absolute reconstruction error of R-peaks was 37 (95% CI, 36-37) μV , T-peaks = 42 (95% CI, 41-43) μV , P-peaks = 39 (95% CI, 38-40) μV , R-R interval = 12.8 (95% CI, 12.3-13.3) ms, PR-interval = 6.7 (95% CI, 6.6-6.9) ms and QT-interval = 37.7 (95% CI, 36.7-38.7) ms.

Conclusion: We show that 10-second, 12-lead ECGs can be reconstructed from 2.5-second Cabrera-format segments using a U-Net model, yielding highly correlated waveforms and clinically acceptable interval estimates, indicating that complete temporal information may be recoverable from digitized paper ECGs and thus improve the value of historical ECG archives.

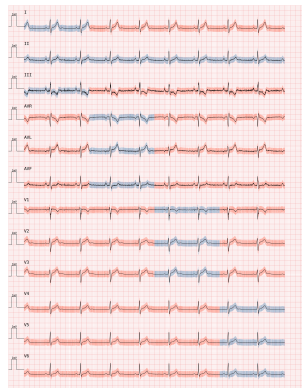


Figure 1. Blue segments are ECG traces already digitized from paper; red segments are those still needing reconstruction.