Transforming ECG into a Poincaré Plot-Based Image for Its Quality Assessment Through a Pre-trained Convolutional Neural Network

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Background and Aim. Wearable ECG acquisition systems present the potential to continuously monitor cardiac activity without altering the patient's daily life. However, the acquired ECG signals are often disturbed by noise and their automated quality assessment is crucial. For this purpose, pre-trained 2-D convolutional neural networks (CNNs) have recently reported promising performance. Hence, this work aims to explore whether ECG transformation using a common approach specifically designed to visualize and feature non-linear, complex, and chaotic dynamics in a time series, such as the Poincaré Plot (PP), might be helpful in ECG quality assessment.

Methodology. To transform an ECG segment into a 2-D image, it was firstly preprocessed and then represented as a PP with embedding dimension of 2 samples and a time delay of 1 sample. Next, the graph was divided into a grid of 227×227 cells and a Jet colormap with 128 colors was applied to the range of values obtained by computing the logarithm of the number of points in each grid cell. The resulting image was used to feed a pre-trained CNN structure. To serve as a reference, this network was also inputted by using scalograms obtained by the Continuous Wavelet Transform (CWT).

Results. The two generated CNN-based models were trained and tested using two different databases. No statistically significant variations in global terms of balanced accuracy (BAcc) and F_1-score were reported. However, the PP-based images presented significantly larger values of specificity (Sp), whereas CWT obtained higher values of sensitivity (Se). Of note is also that the first model was about 3 times faster.

Significance. The ECG transformation into a PP-based image has proven to be a quick and useful approach for its quality assessment using CNNs. Moreover, its performance seems complementary to that of the same CNN inputted with CWT-based ECG images, and a combination of both will have to be explored in search of a better detection of low-quality excerpts.

ECG Image	Se	Sp	BAcc	F_1	Time/ECG interval (ms)
PP-based	0.839	0.897	0.868	0.911	14
CWT-based	0.904	0.810	0.857	0.947	42