Scalable, Multiplatform, and Autonomous ECG Processor Supported by AI for Telemedicine Center

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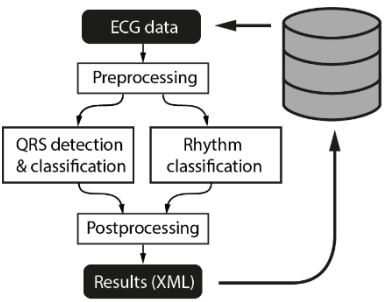
Background: Wearable devices play an important role in the early diagnosis of heart diseases. However, effective management of long-term Holter measurements (1-3 weeks) by a telemedicine center (TMC) requires specifically designed software. It is required to process ECG data from multiple devices instantly; data are usually noisy since patients are recorded during usual daily activities, and they attach ECG electrodes by themselves. Still, TMC operators must be informed about life-threatening events, but they should not be distracted by false-positive cases. We aimed to develop a scalable, multiplatform back-end application to process ECG data in a TMC.

Method: We used the multiplatform framework .NET to build the application. Deep-learning models for QRS detection, classification, and rhythm analysis were trained in the PyTorch framework; models were prepared using ECG data (N=73,450) from Medical Data Transfer, s. r. o., Czechia. The ONNX runtime libraries were used for model inference, including acceleration by graphic cards when available.



Results: We developed the "JOSEPH solver," a multiplatform application to classify one-lead ECG signals from Holter devices. The last stable version, 0.3.110, was deployed on five virtual and one physical computer. These instances have been simultaneously analyzing ECG signals from a shared network location since Nov. 2021 without a crash. The current load is approximately 2,500x 1-hour ECG recordings per day. The pre-production benchmark (82 patients) showed a weighted mean F1 performance of 0.97 ± 0.10 for QRS detection and classification into three classes (normal beats, premature ventricular contractions, and premature atrial contractions). It also showed a mean F1 performance of 0.96 ± 0.02 for rhythm classification into seven classes.

Conclusion: The "JOSEPH solver" is a fully automated, multiplatform, and scalable back-end application to process incoming ECG data in the TMC. Although it is not freely accessible, we are open to processing ECG data for research and non-commercial purposes.