On Edge Wearable ECG Signal Quality Assessment using Residual Hermite Projection and Liquid State Machine, a Hierarchical Domain Adaptation Approach

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Aims: Real-time signal quality assessment of Electrocardiogram (ECG) is a crucial step in remote patient monitoring to mitigate noise impact in wearable devices and to facilitate cost-saving clinical care by reducing the need for clinical staff interventions. We present a low-cost technique for the quality assessment of ECG signals using supervised Hermite projection and Reservoir computing, deployable on neumorphic hardware.

Methodology: First, a Variable Projection Neural Networks (VPNN) with Hermite bases is trained on single-channel ECG epochs of one second. Then, the residual between each input epoch and its reconstruction is passed through a Poisson rate encoder of length T. The Poisson spike train is then fed to a Liquid State Machine (LSM). To classify ECG epochs into three classes: good, intermediate, and bad; a linear Support Vector Machine (SVM) is trained on LSM spiking outputs at time T to perform a crisp distinction between good-intermediate and bad classes. The distinction between good and intermediate is achieved by training another linear SVM on the subset of LSM outputs corresponding to epochs predicted as good-intermediate by the former SVM.

Results: ECG signals from the publicly available Brno University of Technology ECG Quality dataset are first decimated from 1000 Hz to 250 Hz. Then, the ECG signals are split into epochs of one second, and ground-truth labels are populated accordingly. With a training-test split ratio of 70-30 and using a Hermite VPNN regressor with 25 coefficients, a Poisson rate encoder with a length of 20, and an LSM with 1000 neurons, in 10 repetitions over the test-set, the average F1 scores of 99.1% and 76.26% are obtained in the classification of good-intermediate vs bad and good vs intermediate, respectively.

Conclusion: Due to the model's discriminatory ability and one-second temporal resolution, its predictions can be translated into actionable alarms.

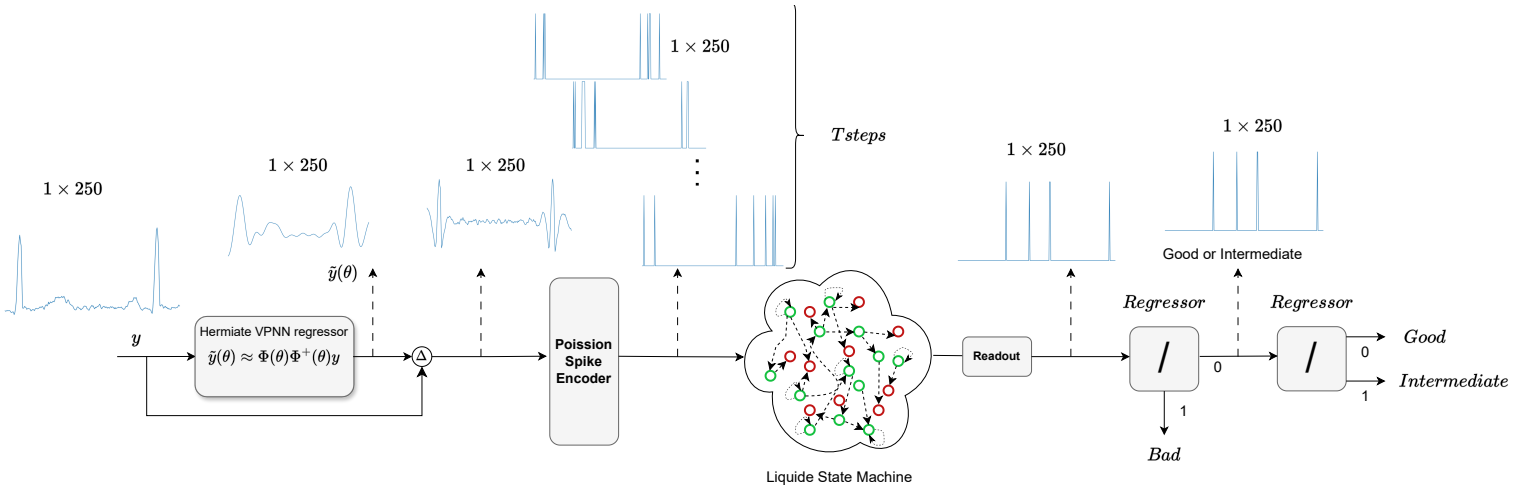

Figure 1. Block diagram of the proposed technique