

Self-Supervised Pretraining with QCGAN-Synthesized ECGs for Abnormality Classification

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Quantum generative modeling has attracted attention as a potential approach for medical time-series AI, where limited labeled data, class imbalance, and acquisition heterogeneity hinder robust representation learning. Because ECG diagnostic information is encoded in waveform morphology, periodicity, and temporal dependencies, we investigate whether ECGs synthesized by quantum conditional generative adversarial networks (QCGANs) [1] can benefit self-supervised pretraining for downstream abnormality classification. We compare three conditions of generative models under matched conditions: quantum-generator/quantum-discriminator, quantum-generator/classical-discriminator, and classical-generator/classical-discriminator. After training generative models with MIT-BIH dataset [2], we obtained synthetic ECG segments from each model by concatenating generated segments into 10-second sequences for masked autoencoder (MAE) pretraining [3], followed by fine-tuning on PTB-XL [4]. Evaluation used 13 Normal-versus-abnormal binary classification tasks from PTB-XL, spanning arrhythmic, conduction, ischemic, infarction-related, and hypertrophy-related abnormalities. The primary metric was positive-class F1-score at a fixed decision threshold of 0.5. The quantum-generator/quantum-discriminator configuration achieved the highest average F1-score: 0.8255, compared with 0.8180 for the quantum-generator/classical-discriminator model and 0.8103 for the classical-generator/classical-discriminator baseline. The quantum-generator/quantum-discriminator model was best in 8 of 13 tasks and improved over the classical-generator/classical-discriminator baseline in 12 of 13 tasks, with an average gain of +0.0152. These results provide initial evidence that QCGAN-synthesized ECGs can benefit self-supervised pretraining for downstream ECG abnormality classification. The improvement over the classical-generator/classical-discriminator baseline suggests that quantum-generated waveforms may provide useful training signals for MAE-based ECG representation learning. Future work will examine statistical robustness, physiological plausibility, GAN stabilization, and quantum circuit ablations.

References

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