SimGANs: Simulator-Based Generative Adversarial Networks for ECG Synthesis to Improve Deep ECG Classification

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A. Additional Experiments

We add additional experiments to demonstrate the contribution of SimGAN.

ECG Generation using WGANs We train a Wasserstein-GAN (Arjovsky et al., 2017) which minimizes the approximation of the Earth-Mover (EM) distance instead of the cross-entropy. The WGAN is trained without adding the euler loss term to the generator optimization.

ECG Generation using SimWGANs We train a Wasserstein-GAN with the Euler additional optimization loss added to the generator.

Non-DL model We add an additional experiment with a non-DL model, which extracts ECG morphological features and then feeds them to a linear regression classifier.

We use the trained generators to generate synthetic ECG heartbeats, and add them to the base set which are than used to train the ResNet convolutional ECG heartbeat classifier.

Table 1. Comparison between Non-DL model, WGAN and SimWGAN. Best results are shown in bold and *.

	LINEAR DISCRIMINANT		WGAN		SIMWGAN	
HEARTBEAT CLASS	RE	PR	RE	PR	RE	PR
SVEB (S)	0.4	0.41	0.4	0.5	***0.5**	***0.63**
VEB (V)	0.76	0.81	0.85	0.83	***0.85**	***0.87**

Table 1 shows that for both type of classes, adding synthetic heartbeats generated from WGAN or SimWGAN to the training set, significantly outperforms classification performance compared to the performance of using only the original training set to train a linear discriminant. However, SimWGAN outperforms WGAN model across both classes. We conclude that adding the Euler loss term to a Wasserstein-GAN which minimizes the EM distance instead of the cross-entropy loss, improves its ability to generate realistic ECG heartbeats.

References

Arjovsky, M., Chintala, S., and Bottou, L. Wasserstein gan. *arXiv preprint arXiv:1701.07875*, 2017.

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