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cDVGAN: Improved Conditional GANs for Generalized Gravitational Wave Transient Generation

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We present Conditional Derivative GAN (cDVGAN), a novel conditional GAN framework for simulating multiple classes of gravitational wave (GW) transients in the time domain. cDVGAN can also generate generalized hybrid waveforms that span the variation between waveform classes through class-interpolation in the conditioned class vector. cDVGAN transforms the typical 2-player adversarial game of GANs into a 3-player game with an auxiliary critic analyzing the derivatives of time series signals. Our results show that this provides synthetic data that better captures the features of the original waveforms. cDVGAN conditions on three waveform classes, two preprocessed from LIGO *blip* and *tomte* glitch classes from its 3rd observing run (O3), and the third representing binary black hole (BBH) mergers. Our proposed cDVGAN outperforms 4 different baseline GAN models in replicating the features of the three waveform classes. Specifically, our experiments show that training convolutional neural networks (CNNs) with our cDVGAN generated data improves the detection of waveforms embedded in detector noise beyond the synthetic data from other *state-of-the-art* GAN models. Our best synthetic dataset yields as much as a 7% increase in *area-under-the-curve* (AUC) performance compared to the next best synthetic dataset from baseline GANs. Moreover, training the CNN with hybrid waveforms from our cDVGAN outperforms CNNs trained only on the standard waveform classes when identifying real signals embedded in LIGO detector background between SNRs ranging from 1 to 16. Lastly, we illustrate cDVGAN as a viable data augmentation method that can surpass the performance of using a traditional data augmentation approach.

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