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# Information-theoretic stochastic contrastive conditional GAN (InfoSCC-GAN) for physical data generation

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Cosmological simulations use generative deep learning models to generate galaxy images that are indiscernible from real images. Such simulations allow for a precise modeling of competing cosmological models as well as realistic propagation effects that affect observations. We present a new stochastic contrastive conditional generative adversarial network (InfoSCC-GAN) with explorable latent space that can be used for generation of natural images as well as images of galaxies.
The InfoSCC-GAN architecture is based on an unsupervised contrastive encoder built on the InfoNCE paradigm, attributes' classifier, and stochastic EigenGAN generator. We propose two approaches for selecting the class attributes: external attributes from the dataset annotations and internal attributes from the clustered latent space of the encoder. We propose a novel training method based on a generator regularization using external or internal attributes every $n$-th iteration using the pre-trained contrastive encoder and pre-trained attributes' classifier. The proposed InfoSCC-GAN is derived from an information-theoretic formulation of mutual information maximization between the input data and latent space representation for the encoder and the latent space and generated data for the decoder. Thus, we demonstrate a link between the training objective functions and the above information-theoretic formulation. The experimental results show that InfoSCC-GAN outperforms vanilla EigenGAN in image generation on several popular datasets, yet providing an interpretable latent space. In addition, we investigate the impact of regularization techniques and each part of the system by performing an ablation study.
Finally, we demonstrate that thanks to the stochastic EigenGAN generator, the proposed framework enjoys a truly stochastic generation of natural images and galaxy images in contrast to vanilla deterministic GANs yet with the independent training of an encoder, a classifier, and a generator.

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