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Turbo-Sim: a generalised generative model with a physical latent space

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We present Turbo-Sim, a generalised autoencoder framework derived from principles of information theory that can be used as a generative model. By maximising the mutual information between the input and the output of both the encoder and the decoder, we are able to rediscover the loss terms usually found in adversarial autoencoders and generative adversarial networks, as well as various more sophisticated related models. Our generalised framework makes these models mathematically interpretable and allows for a diversity of new ones by setting the weight of each loss term separately. The framework is also independent of the intrinsic architecture of the encoder and the decoder thus leaving a wide choice for the building blocks of the whole network.

We apply Turbo-Sim to a collider physics generation problem: the transformation of the properties of several particles from a theory space, right after the collision, to an observation space, right after the detection in an experiment. We show that our model is able to compete with state-of-the-art method, even outperforming it in critical tasks. Moreover, these results are reached with very basic network building blocks, which is a crucial observation in view of future more expressive implementations.

Another interesting application of such a model is to use it for unfolding tasks. An important aspect of particle physics analysis is also to get back from the observed data to the actual physics. Thanks to the paradigm of using a physically meaningful latent space, i.e. the theoretical distributions of energy and momenta of a given scattering process, our Turbo-Sim model is also trained to achieve this task.

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