Learning Probabilistic Models from Generator Latent Spaces with Hat EBM

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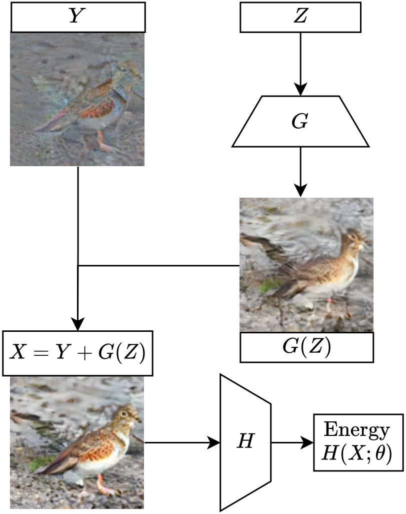
Hat EBM Introduction



- We propose a method for building an Energy-Based Model (EBM) on top of a generator network, called the **Hat EBM**
- The energy is defined jointly over a latent vector Z and residual image Y
- To get the joint energy, we generate an image $G(Z)$, add the residual Y, and pass the sum through the hat network $H(X;\theta)$

Motivation

- Defining a probability distribution over the output of a generator network is challenging
  - Density change-of-variables is one way, but requires log determinant of generator Jacobian
  - Inferring latent states of observed data is another way (Latent Prior EBMs), but requires MCMC or inference network
- We introduce a residual image to adjust the output of the generator. Formulation bypasses both generator Jacobian and inference of latents states for observations
- Generator learns overall image structure while residuals capture fine-grain details

Hat EBM Model Formulation

Joint Energy over Latent and Residual Space

$$p(y, z; \theta) = \frac{1}{\mathcal{Z}(\theta)} \exp\{-H(G(z) + y; \theta)\}$$

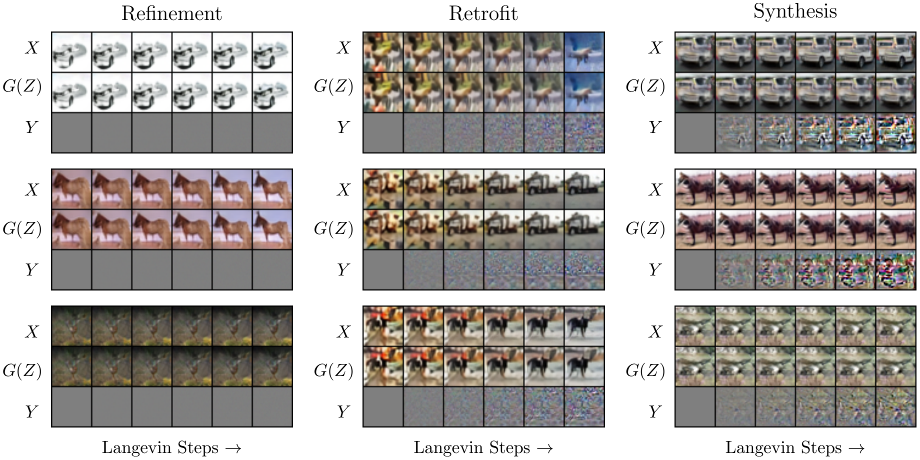
Applications: Generator Refinement, EBM with Deterministic Autoencoder

Residual Energy Conditioned on Latent State

$$p(y, z; \theta) = \frac{1}{\mathcal{Z}_z(\theta)} p_0(z) \exp\{-H(G(z) + y; \theta)\}$$

Applications: Image Synthesis, OOD Detection

Hat EBM Sampling Paths

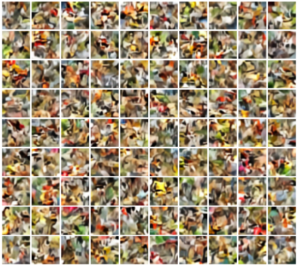


Refinement and Retrofit Experiments

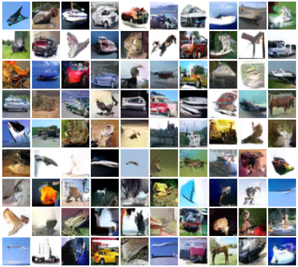
Refining SN-GAN Generators

Model	CIFAR-10 FID	CelebA FID
SN-GAN (baseline)	18.58 $\pm$ 0.08	6.13 $\pm$ 0.03
DDLS	14.59 $\pm$ 0.07	6.06 $\pm$ 0.01
Hat EBM	**14.04** $\pm$ **0.11**	**5.98** $\pm$ **0.02**

Hat EBM with Generator from Deterministic Autoencoder



Initial States



Short-Run MCMC Samples
FID 26.01

Hat EBM for Synthesis

CIFAR-10 (32 × 32)

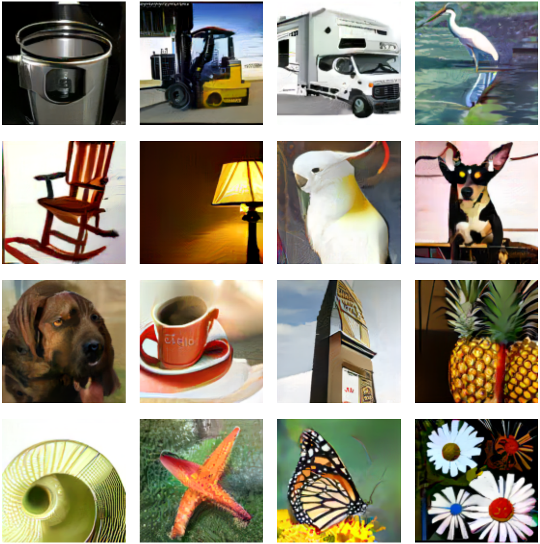
Model	FID
Hat EBM (*Ours*)	**19.30 ± 0.15**
Improved CD EBM	25.1
VERA	27.5
Cooperative EBM	33.6
Flow EBM	37.3
JEM	38.4
IGEBM	40.6
DDPM	**3.2**
NCSNv2	10.9
SN-GAN	18.6

CelebA (64 × 64)

Model	FID
Hat EBM (*Ours*)	**11.57 ± 0.04**
Divergence Triangle	31.9
SN-GAN	**6.1**
NCSNv2	10.2

ImageNet (128 × 128)

Model	FID
Hat EBM (*Ours*)	**40.24 ± 0.18**
SN-GAN	65.7
SS-GAN	43.9
InfoMax GAN	58.9
Hat EBM, scaled (*Ours*)	29.37 ± 0.15
SS-GAN, scaled	**23.4**



Thank you!

Code and pretrained models available at

https://github.com/point0bar1/hat-ebm