



THE UNIVERSITY OF  
CHICAGO

COMPUTATIONAL AND APPLIED MATHEMATICS STUDENT SEMINAR

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VAEBM: A Symbiosis Between Variational Autoencoders and  
Energy-based Models

*(Joint work with Karsten Kreis, Jan Kautz, Arash Vahdat)*

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ABSTRACT

Energy-based models (EBMs) have recently been successful in representing complex distributions of small images. However, sampling from them requires expensive Markov chain Monte Carlo (MCMC) iterations that mix slowly in high dimensional pixel space. Unlike EBMs, variational autoencoders (VAEs) generate samples quickly and are equipped with a latent space that enables fast traversal of the data manifold. However, VAEs tend to assign high probability density to regions in data space outside the actual data distribution and often fail at generating sharp images. In this paper, we propose VAEBM, a symbiotic composition of a VAE and an EBM that offers the best of both worlds. VAEBM captures the overall mode structure of the data distribution using a state-of-the-art VAE and it relies on its EBM component to explicitly exclude non-data-like regions from the model and refine the image samples. Moreover, the VAE component in VAEBM allows us to speed up MCMC updates by reparameterizing them in the VAE's latent space. Our experimental results show that VAEBM outperforms state-of-the-art VAEs and EBMs in generative quality on several benchmark image datasets by a large margin. It can generate high-quality images as large as  $256 \times 256$  pixels with short MCMC chains. We also demonstrate that VAEBM provides complete mode coverage and performs well in out-of-distribution detection.