Moment Guided Diffusion for Maximum Entropy Generation

E. Lempereur, N. Cuvelle-Magaar, F. Coeurdoux
S. Mallat, E. Vanden-Eijnden
École Normale Supérieure, Capital Fund Management

December 12, 2025

Abstract

Maximum entropy methods provide explicit exponential models of probability densities from a family of moments. Parameter estimation and sampling with MCMC or Langevin algorithms suffer from exponential slowdown when crossing Gibbs energy barriers, and are thus untractable in high dimension. We introduce a Moment Guided Diffusion (MGD) which samples maximum entropy distributions by transporting a Gaussian distribution with a Stochastic Different Equation (SDE). It guides moments with a drift term and avoids the exponential slow-down. Under appropriate assumptions the transport converges to the maximum entropy distribution, when the volatility of the SDE increases, which is validated numerically. An estimation of the resulting maximum entropy is calculated from the MGD parameters. The MGD algorithm is applied to generate high-dimensional maximum entropy models of multiscale financial time series as well as turbulence and cosmological fields, with wavelet scattering moments. It provides the first estimations of the negentropy for such high-dimensional random processes, which is the measure of non-Gaussianity in information theory.