The Hong Kong University of Science and Technology

Seminar on Rusiness Data Science

Department of ISOM

Non-asymptotic bounds on the forward process in denoising diffusions

By

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Date: 11 June 2025 (Wednesday) Time: 3:00pm – 4:00pm Venue: Room 4047 (LSK Business Building)

Abstract

Denoising diffusion probabilistic models (DDPMs) represent a recent advance in generative modelling that has delivered state-of-the-art results across many domains of applications. Despite their success, a rigorous theoretical understanding of the error within DDPMs, particularly the non-asymptotic bounds required for the comparison of their efficiency, remain scarce. Making minimal assumptions on the initial data distribution, allowing for example the *manifold hypothesis*, in this talk I will present explicit non-asymptotic bounds on the forward diffusion error in total variation (TV), expressed as a function of the terminal time T.

The key idea is to parametrise multi-modal data distributions in terms of the distance \$R\$ to their furthest modes and consider forward diffusions with additive and multiplicative noise. Our analysis rigorously proves that, under mild assumptions, the canonical choice of the Ornstein-Uhlenbeck (OU) process cannot be significantly improved in terms of reducing the terminal time \$T\$ as a function of \$R\$ and error tolerance \$\epsilon>0\$. Motivated by data distributions arising in generative modelling, we also establish a cut-off like phenomenon (as \$R\to\infty\$) for the convergence to its invariant measure in TV of an OU process, initialized at a multi-modal distribution with maximal mode distance \$R\$. This is joint work with Miha Brešar at Warwick.

Bio

Aleks Mijatović is Professor of Probability at the Statistics Department at Warwick. He has broad interests in Probability and its applications, including Data Science & Foundations of Machine Learning, Simulation & Monte Carlo, Statistics, Mathematical Finance, Analysis and Geometry. For more information, see his research YouTube channel <u>Prob-AM</u> and <u>webpage</u>.

All interested are welcome!

For details, please contact ISOM Department.