

Exponential integrators for generative diffusion models

Zheng Zhao

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1 Background

Generative diffusion models are recently successful methods for many applications (e.g., image generation). An important question is how to improve the sampling quality *after the fact* that a model has been trained. In this project, we will leverage the structure of the denoising process, to develop new sampling algorithms based on exponential integrators. Details will be given to the student at the initial meeting.

2 Learning outcomes

You will substantially learn new knowledge in statistical machine learning as well as practical skills:

- Generative diffusion models, a trending research topic in machine learning.
- Numerical techniques for simulating stochastic differential equations.
- JAX/PyTorch, two popular Python libraries for machine learning.

3 Reading list

Song, Yang, et al. Score-based generative modeling through stochastic differential equations. In *International Conference on Learning Representations*, 2021.

Zheng Zhao, Ziwei Luo, Jens Sjölund, and Thomas B. Schön. Conditional sampling within generative diffusion models. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 383(2299):20240329, 2025.

Buckwar, Evelyn, Martin G. Riedler, and Peter E. Kloeden. The numerical stability of stochastic ordinary differential equations with additive noise. *Stochastics and Dynamics 11*, 2011.

4 Eligibility requirements

- Strong background in statistical machine learning is necessary.

5 Contact

We implement a *interest-selection-meeting-agreement* procedure. You contact us if you feel interested in this topic, and then we will get back to you for a meeting if we find you potentially suitable. At the meeting, we will give you full details of the project. You will then have a few days to think whether you indeed want to do this project and get back to us with yes/no. If we both agree, we will come up with a concrete plan and project starts.

To apply, please send an email to Zheng Zhao (email: zheng.zhao@liu.se) *with your CV and transcripts enclosed*.