On the Accuracy of Diffusion Models in Bayesian Image Inverse Problems: A Gaussian Case Study

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When used as priors for Bayesian inverse problems, diffusion models have demonstrated remarkable effectiveness in recent literature [2]. Their inherent flexibility and high variance allow them to produce diverse solutions for image restoration tasks, including inpainting, super-resolution, and denoising. Despite these advances, several fundamental questions remain regarding their accuracy. In this talk, we examine the performance of diffusion-based priors in a simplified setting where the data follow a Gaussian distribution. Within this framework, we rigorously quantify the discrepancy between the theoretical solution of the inverse problem and the approximation provided by diffusion models. This is achieved by computing the Wasserstein distance between the distribution induced by the diffusion model sampler and the exact posterior distribution. Our study focus on the DPS [1] and the ΠGDM [3] algorithms.

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[2] G. Daras, H. Chung, C.-H. Lai, Y. Mitsufuji, P. Milanfar, A. G. Dimakis, C. Ye, M. Delbracio. *A survey on diffusion models for inverse problems*, 2024.

[3] J. Song, A. Vahdat, M. Mardani, J. Kautz. *Pseudoinverse-guided diffusion models for inverse problems.* In *International Conference on Learning Representations*, 2023.

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