Fourier Compressed Sensing in MRI using a Pretrained Diffusion Model

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1 Introduction

Fourier Compressed Sensing (Fourier CS) applies compressed sensing techniques to measurements taken in the discrete Fourier transform (DFT) domain of an image. This approach frames image reconstruction as an inverse problem, which can be addressed using diffusion models, such as Diffusion Posterior Sampling [1].

Fourier CS is particularly relevant to MRI, where data is naturally acquired in the Fourier domain. Image reconstruction typically involves applying an inverse Fourier transform. Accelerating MRI acquisition by reducing the amount of acquired data is critical, as longer scan times increase susceptibility to motion artifacts and reduce clinical accessibility. This challenge is especially significant for pediatric patients, who may require sedation during scans, introducing potential long-term risks.

In this project, I will begin with the default DiffusionProject, which focuses on solving various inverse problems, including image inpainting and deconvolution. Building on this foundation, I will extend the methodology to address the Fourier CS problem. Specifically, I will use a pretrained latent diffusion model [2] to reconstruct images from undersampled MRI data and compare its performance against other reconstruction techniques.

2 Related Work

Several previous studies have explored learning-based models for Fourier Compressed Sensing. E2E-VarNet[3] proposed a method for filling missing Fourier domain data using a physics-based model, while MoDL[4] introduced a model-based image reconstruction framework that incorporates convolutional neural network (CNN)-based regularization.

Given that Fourier CS is formulated as an inverse problem, I plan to leverage Diffusion Posterior Sampling (DPS)[1] to address it. Specifically, I will utilize a pretrained Latent Diffusion Model[2], such as the one used in Stable Diffusion, to perform the reconstruction. Applications of latent diffusion models to inverse problems have been explored in [5].

3 Methodology and Experiments

This project focuses on applying a pre-trained diffusion model to various inverse problems. If time permits, I will compare the results between traditional model-based methods and the diffusion-

based approach for the Fourier Compressed Sensing problem. As **this is an individual project** with limitations in both time and computational resources, the scope will be narrowed to relatively simple tasks to ensure feasibility.

4 Timeline

- **Feb 21 - Mar 2**: Complete the default project and select suitable datasets for Fourier CS.
- **Mar 3 - Mar 11**: Implement Fourier CS with the pre-trained Latent Diffusion Model and conduct ablation studies.

References

[1] Chung, Hyungjin, et al. "Diffusion posterior sampling for general noisy inverse problems." arXiv preprint arXiv:2209.14687 (2022).

[2] Rombach, Robin, et al. "High-resolution image synthesis with latent diffusion models." Proceedings of the IEEE/CVF conference on computer vision and pattern recognition. 2022.

[3] Sriram, Anuroop, et al. "End-to-end variational networks for accelerated MRI reconstruction." Medical image computing and computer assisted intervention–MICCAI 2020: 23rd international conference, Lima, Peru, October 4–8, 2020, proceedings, part II 23. Springer International Publishing, 2020.

[4] Aggarwal, H. K., Mani, M. P., and Jacob, M. (2018). MoDL: Model-based deep learning architecture for inverse problems. IEEE transactions on medical imaging, 38(2), 394-405.

[5] Rout, Litu, et al. "Solving linear inverse problems provably via posterior sampling with latent diffusion models." Advances in Neural Information Processing Systems 36 (2023): 49960-49990.