Deep generative model-based network for accelerated MRI reconstruction

Supervisor(s):

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Project description:

Generative modelling has shown to be powerful and popular in many computer vision applications such as image generation and image super-resolution. MRI reconstruction is similarly an inverse problem which recovers a complex-valued image from its under-sampled acquired raw data.

The goal of this project is to develop a novel deep generative model based on diffusion models or flow matching for MRI reconstruction from accelerated acquisitions. The proposed approach will build on our previously developed model-based DL methods where the physically acquired raw data will be incorporated into the generative model throughout the reconstruction process for improved reliability. We will also aim to capture the prior knowledge from the large amount of magnitude images and adapt it to complex-valued MRI reconstruction via manifold traversing or distribution matching, and therefore potentially reconstruct MRI in an unsupervised way. The generative nature of the approach will also guarantee its ability in quantifying the predictive uncertainty of the reconstruction by sampling from the generative latent space, providing a measure of the model's predictive confidence and informing its reliability. This would overcome the current limitations of the lack of AI trustworthiness considerations in MRI reconstruction.

Timeline (tentative):

Oct - Jan: Literature review;
Jan - May: Method development;
May - Jul: Experiments and model refinement;
Jul - Aug: Writing up.

Minimum viable thesis:

The minimum viable thesis is to adapt and implement a variation of an existing diffusion model developed in computer vision tasks to the new application of MRI reconstruction.

Required background & skills:

Proficiency in Python and Pytorch/Tensorflow is essential. Knowledgeable in deep learning and computer vision is essential. Experience in processing medical images is desired.

Representative References:

[1] Qin, Chen, et al. "Convolutional recurrent neural networks for dynamic MR image reconstruction." IEEE transactions on medical imaging 38.1 (2018): 280-290.
[2] Luo, Guanxiong, et al. "Bayesian MRI reconstruction with joint uncertainty estimation using diffusion models." Magnetic Resonance in Medicine 90.1 (2023): 295-311.
[3] Chung, Hyungjin, et al. "Improving diffusion models for inverse problems using manifold constraints." Advances in Neural Information Processing Systems 35 (2022): 25683-25696.
[4] Lipman, Yaron, et al. "Flow matching for generative modeling." arXiv preprint arXiv:2210.02747 (2022).