Dynamic Magnetic Resonance Sampling Pattern Guided by Deep Reconstruction

Zaimin Zhu[a], Fangrong Zong[a]
[a]School of Artificial Intelligence, Beijing University of Posts and Telecommunications, Beijing, China.

Introduction: K-space undersampling is a primary method for reducing MRI scan time. Existing undersampling techniques typically rely on predefined static sampling patterns [1,2], neglecting inter-individual anatomical variations. This study introduces a deep learning-guided (DL-guided) sampling pattern which dynamically determine the k-lines to be sampled during the 3D k-space sampling process.

Methods: Figure 1 shows the proposed approach: k-space is progressively filled over multiple scans using a 3D EPI sequence, with the k-lines to be acquired in each scan determined by the already collected data. During the first scan, 10% of the k-lines are randomly chosen according to a Gaussian distribution. After each scan, the undersampled image is zero-padded and input into a U-Net model to predict the fully sampled image. The residual image between the undersampled and predicted fully sampled images is transformed into k-space residuals via Fourier transform. The 10% of k-lines with the largest absolute residuals in unsampled regions are acquired in the next scan.

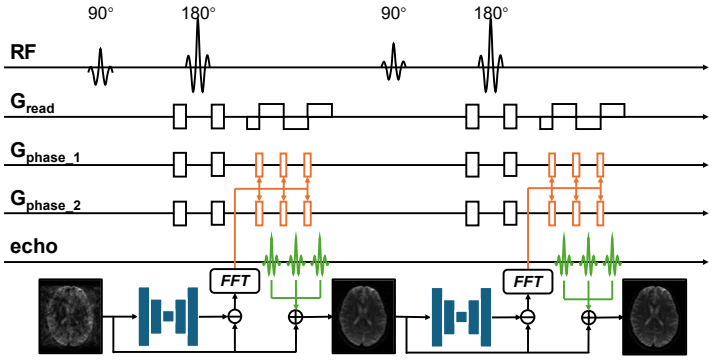

Fig. 1. The training framework of DL-guided sampling pattern.

Results and dissemination: The effectiveness of the proposed method was validated through simulations on the Human Connectome Project (HCP) dataset [3]. As shown in Figure 1, at low sampling rates, the DL-guided sampling pattern significantly outperforms fixed sampling patterns generated by Gaussian or uniform distributions in terms of reconstruction quality. Figure 2 illustrates the images obtained using the DL-guided pattern and the Gaussian pattern at different sampling rates. Notably, the DL-guided pattern achieves image quality comparable to that of a 40% Gaussian pattern even at a 20% sampling rate.

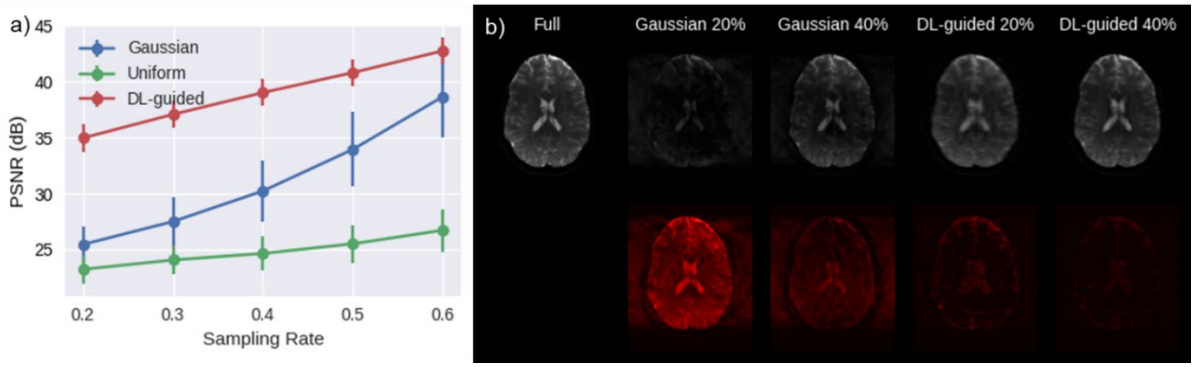

Fig. 2. a) The variation of reconstruction accuracy with sampling rate under different sampling pattern; b) MRI acquired with at different patterns and sampling rates

Conclusion: This study presents a deep learning-guided k-space undersampling method that enables accurate imaging at low sampling rates.

References: [1] Levine E., IEEE Trans Med Imaging(2017). [2] Sherry, F., IEEE Trans Med Imaging(2020). [3] Van Essen, D. C., Neuroimage(2013).

Acknowledgement: This work was supported by the National Natural Science Foundation of China (No. 82371910).