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A Deep Unrolled Neural Network for Multi-Shot MRI Reconstruction

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Multi-shot MRI acquisitions, including multi-shot echo-planar imaging (msEPI) and PROPELLER/BLADE, offer key advantages over conventional single-shot methods. msEPI enables high-resolution, distortion-minimized diffusion imaging, while PROPELLER/BLADE trajectories inherently correct for in-plane motion, making them well suited for applications such as brain and liver MRI. Nevertheless, multi-shot acquisitions are often limited by phase inconsistencies across shots and the computational cost of reconstruction.

Recent progress in deep unrolled neural networks provides an effective solution by combining physics-based forward models with learned regularization. In supervised learning settings, such networks substantially accelerate reconstruction—reducing processing times from minutes to seconds—while preserving high image fidelity. This acceleration makes multi-shot acquisitions more feasible for clinical and research use.

In cases where ground-truth training data are unavailable, for instance in high-noise datasets or unique acquisition protocols, zero-shot self-supervised learning (ZS-SSL) has emerged as a valuable alternative. Unlike supervised methods, ZS-SSL does not depend on external datasets but instead adapts to scan-specific conditions. While not always benchmarked against state-of-the-art supervised techniques, ZS-SSL demonstrates particular utility in challenging scenarios: in BUDA-cEPI diffusion MRI, it improves noise suppression and fiber delineation, while in highly accelerated PROPELLER imaging it effectively reduces noise amplification, thereby maintaining diagnostic utility even under aggressive undersampling.

Overall, the integration of deep unrolled networks with multi-shot acquisitions highlights a trade-off between speed and robustness: supervised learning offers rapid reconstructions well suited for routine use, while ZS-SSL provides greater adaptability and noise resilience in difficult conditions. Together, these approaches advance the practicality of multi-shot MRI toward broader deployment.

Keywords: *Multi-shot MRI, EPI, PROPELLER, Unrolled neural network, Zero-shot self-supervised learning, Diffusion MRI.*