3D Cardiac MRI Cine Image Denoising

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Introduction:

Breath-held segmented bSSFP cine imaging is clinical gold standard for analyzing cardiac function, but it uses ECG gating and requires breath-holds. Our group has developed a continuous-acquisition respiratory and cardiac self-gated cine sequence for free-breathing cardiac function acquisition using 3D stack of spiral gradient echo sequence to perform 3D cine evaluation of the left ventricle[1,2]. However, iterative compressed sensing reconstruction of 3D spiral imaging is time-consuming and not clinically feasible. In this project, we develop high-resolution 3D cardiac cine imaging using rapid spiral acquisitions and deep learning-based imaging reconstruction[3] to enable rapid online reconstruction.

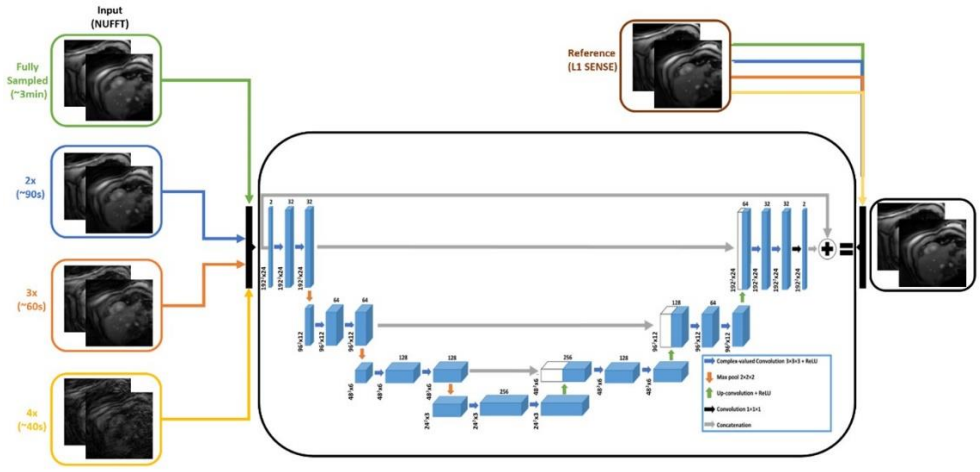
Related Works:

Compressed sensing-based reconstruction method:

One method to reconstruct images is a 3D iterative L1-SENSE–based reconstruction technique[3,4] for 3D SPARCS imaging. The reconstruction pipeline for the reference images uses cardiac self-gating signals to perform retrospective cardiac binning followed by rigid motion correction in k space and auto coil selection over the whole 3D volume.

U-Net Based reconstruction method:

The following figure shows the proposed 3D DESIRE U-Net image reconstruction framework[5]. The training dataset has ~200 slices of 3D SPARCS images from ~20 cases, and the validation data has ~20 slices of 3D SPARCS images from ~2 cases. Different under-sampled rate input images are reconstructed by retrospective down sampling from the fully samples data and using 3D gpuNUFFT with the reference of fully sampled L1 SENSE images. The training of networks (D3K32) was conducted on a single GPU (RTX4090, Nvidia).



Estimation U-Net method:

In this project, we would like to evaluate the U-Net method compared with traditional compressing methods by NRMSE, PSNR and SSIM.

Milestones:

By March 1st: Preprocess the training dataset. Finish the U-Net code.

By March 8th: Training network and tune hyperparameters.

By March 10th: Fine tuning the U-Net, evaluate the performance of U-Net.

By March 15th: Wrap up the code and write report.

Reference:

1. Wang X, Wang J, Zhou R, Salerno M.Rapid Free-breathing 3D SPirAl Respiratory and Cardiac Self-gated (SPARCS) Cine Acquisition Using an Undersampled Stack-of-Spirals. In Proceedings of the ISMRM 30th Annual Scientific Sessions, London, England, UK, 2022
2. Zhou R, Yang Y, Mathew RC, et al. Free-breathing cine imaging with motion-corrected reconstruction at 3T using SPiral Acquisition with Respiratory correction and Cardiac Self-gating (SPARCS). Magn Reson Med. 2019;82(2):706-720.
3. Otazo R, Kim D, Axel L, Sodickson DK. Combination of compressed sensing and parallel imaging for highly accelerated first-pass cardiac perfusion MRI. Magnetic Resonance in Medicine 2010;64:767–776.
4. Feng L, Grimm R, Block KT, et al. Golden-angle radial sparse parallel MRI: Combination of compressed sensing, parallel imaging, and golden-angle radial sampling for fast and flexible dynamic volumetric MRI. Magnetic Resonance in Medicine 2014;72:707–717.
5. Wang J, Weller DS, Kramer CM, Salerno M. DEep learning-based rapid Spiral Image REconstruction (DESIRE) for high-resolution spiral first-pass myocardial perfusion imaging. NMR Biomed. 2022;35:e4661.