Synergistic Image Reconstruction Framework: version 3.2

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INTRODUCTION

- SIRF: a software infrastructure for the reconstruction of biomedical images including simultaneous PET/MR [1].
- In MRI:
  - previous SIRF versions reconstructed only MRIs acquired with Cartesian k-space sampling trajectories.
  - Non-cartesian sampling has properties beneficial for:
    - MR motion robustness and correction,
    - MR fingerprinting for tissue quantification,
    - UTE sequences require a spiral readout for MR bone imaging.

Major updates in release SIRF v3.2 :
MR Reconstruction of 2D non-cartesian trajectories

METHODS

Data Acquisition:

- Verio 3T MR scanner (Siemens, Erlangen, Germany) and 4 channel HeadMatrix coil.
- Vendor-independent sequence using open-source sequence design pypulseq [2]. Slice thickness 5 mm, encoded FOV = 256x256 mm^2
- Phantom data acquisition with cartesian, radial, and spiral trajectories [3,4] for fully sampled (R=1) and 2-fold accelerated spiral and radial, and cartesian GRAPPA 2 acquisitions with 64 reference lines (R=2).

Trajectory	R=1 Readout points | along	R=2 Readout points | along
Cartesian	512 | 256 lines	512 | 96 + 64 lines
Radial	512 | 402 spokes	512 | 201 spokes
Spiral	364 | 402 arms	364 | 201 arms

Reconstruction:

- Trajectory is read from the acquisition file and set as part of the ISMRMRD [5] object.
- Reconstructions for different trajectories were performed using identical reconstruction code at 1mm in-plane resolution:

➢ Pseudo-inverse (PI) using density-compensated FFT for R=1 and R=2.
➢ Conjugate gradient iterative SENSE for R=2 (CG).

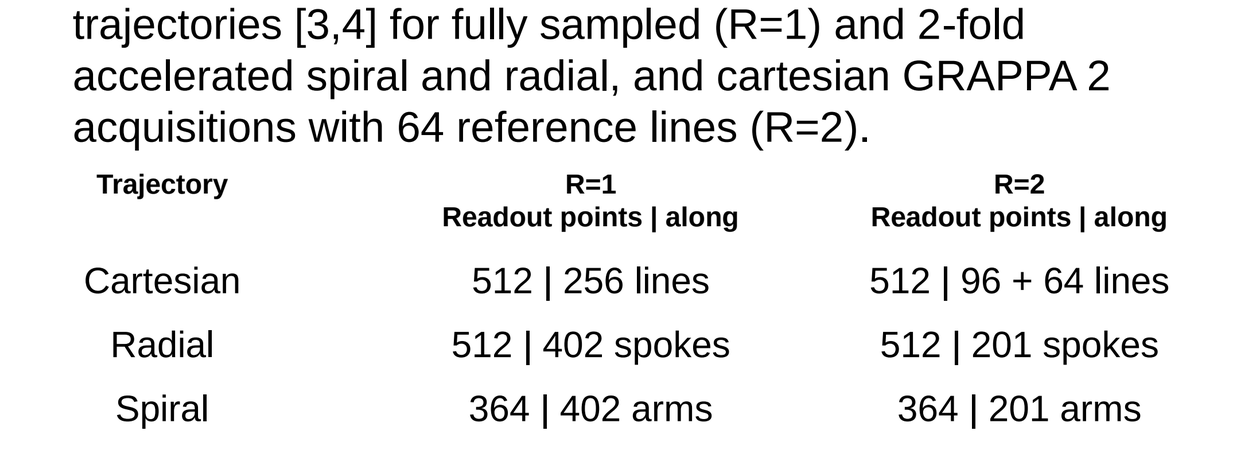

Fig. 1: *Overview of non-cartesian MR reconstruction with SIRF v3.2.* The trajectory information is stored in the ISMRMRD raw data file. The acquisition model handles everything internally and can be used independently of the trajectory. The user need not supply further information.

RESULTS

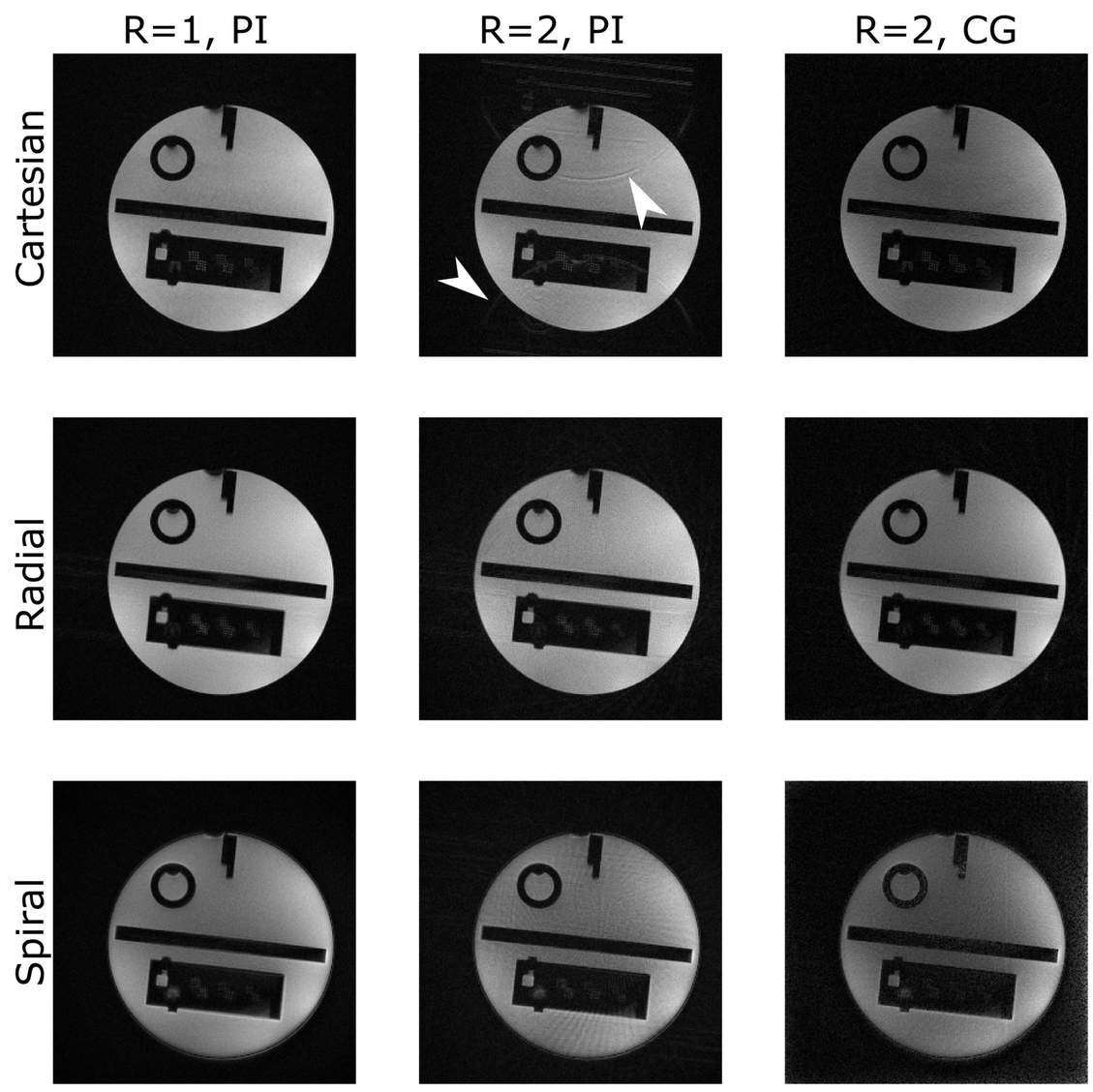

Fig. 2: *comparison of reconstructions using a SIRF acquisition model*. From left to right: fully sampled (R=1) pseudo-inverse (PI), R=2-fold undersampled PI and conjugate gradient (CG) iterative SENSE reconstruction of R=2 data. Reconstructions of all trajectories used identical reconstruction code. High-frequency undersampling artefacts appear more incoherent in non-cartesian reconstructions. Iterative SENSE can reduce undersampling artefacts for all trajectories.

DISCUSSION AND CONCLUSION

- SIRF v3.2 now supports 2D spiral, radial and golden angle reconstructions.
- SIRF generic Acquisition models can be employed in iterative reconstructions of non-cartesian data.
- Minimal user overhead as SIRF handles trajectories internally.

Outlook:

- Step towards enabling MR fingerprinting, model-based MR and synergistic reconstructions.
- SIRF 3.3: SPECT reconstructions and PET reconstruction from listmode data.

Near future:

- Support arbitrary k-space sampling for MR.
- Enable stochastic variance reduction algorithms on PET and SPECT data.
- Preliminary interface to PyTorch.

REFERENCES

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github.com/SyneRBI | github.com/gadgetron | github.com/ismrmrd