SELF-CALIBRATING NONLINEAR RECONSTRUCTION ALGORITHMS FOR VARIABLE DENSITY SAMPLING AND PARALLEL RECEPTION MRI

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ABSTRACT

Compressed Sensing has allowed a significant reduction of acquisition time in MRI, especially in the high resolution (e.g., 400 μm) context. However, in this setting CS must be combined with parallel reception as it maintain high *input* signal-to-noise ratio (SNR). In this setting, reconstruction time becomes a crucial issue especially for non-Cartesian data. Here, we propose a new combination of simple but fast sensitivity maps extraction with new fast nonlinear optimization method (POGM) to speed up the reconstruction stage while maintaining high image quality. We compared our approach with current state of the art (ESPIRiT) both in terms of image quality and computation time.

1. INTRODUCTION

Magnetic Resonnance Imaging (MRI) is a key imaging technique to probe soft tissues (e.g., the brain) non-invasively. However, its acquisition time may be prohibitive in high resolution scenarios. To cope with this issue, Compressed Sensing has been applied to MRI and combined with multiple receiver coils to reduce the acquisition time, while maitaining high input SNR. However, in this setting the reconstruction step became lengthy and many optimization methods tried to diminish this time. To this end, we implemented a novel accelerated proximal optimization method that we combined with a fast estimation of sensitivity maps. Validation is performed on *prospective* non-Cartesian high resolution in-vivo Human brain data.

2. MATERIALS & METHODS

In this work, we focus on the Sparse-SENSE formulation [1].

Sensitivity maps extraction: Since sensitivity maps information lies in the low-frequency domain, variable density sampling schemes like spirals or sparkling [2] intrinsically handle this information and thus are self-calibrating. The sensitivity maps estimation method relies on the extraction of the θ % central surface of the collected measurements (here $\theta = 10$), then the low resolution coil images are reconstructed applying the NFFT adjoint operator to the data. The square root of the Sum of Squares (SOS) is computed before the pixelwise ratio between image coils and the SOS. Noise attenuation in the image background is achieved by masking the estimated sensitivity maps from a binary mask extracted via the SOS.

Optimization algorithm: A fast optimization method is required to reduce the number of iterations. This minimization is tradionally done using a Forward-Backward splitting or one of its acceleration [3], in this work we implement a new acceleration POGM [4].

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3. RESULTS

For validation purposes, we acquired in-vivo anatomical MRI data on healthy volunteers at 7T (Magnetom Siemens scanner) using 1Tx/32Rx head coil (Nova Medical Inc) coil. The Sparkling [2] trajectories (modified 2D T2*-weighted GRE sequence) was implemented to perform prospective CS. The resolution was : $400\,\mu$m and a slice thickness of 3 mm (matrix size of $N = 512 \times 512$). Total acquisition time was 35 s, 8 times shorter than the fully sampled reference. We compared the results of the reconstruction with current state of the art ESPIRiT [5]. For the same input data and on the same architecture, the POGM converges in 35 min compared to 1 hour for ESPIRiT. Moreover, our extraction of sensitivity maps takes less than one minute whereas the ESPIRiT takes about 10 min.

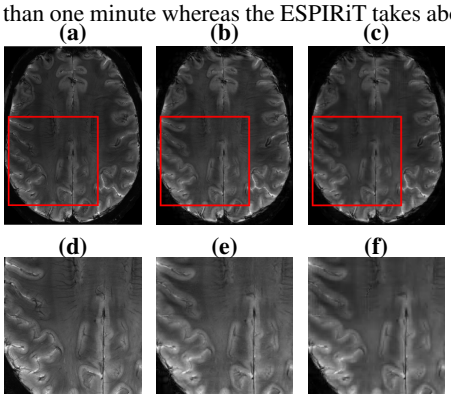

Fig. 1. **(a)** Cartesian reference, **(b)** Self-calibrating POGM-based and **(c)** ℓ_1-ESPIRiT reconstructions. **(d)-(f)** respective zooms in the red square.

4. DISCUSSION AND CONCLUSION

In terms of image quality, our approach provides similar results (pSNR $=$ 27 dB and SSIM $= 0.7$) to the ESPIRiT solution but at a lower computation cost, both regarding reconstruction (2-fold acceleration) and sensitivity maps extraction (10-fold acceleration).

5. REFERENCES

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