CE-MRA with tailored 3D random sampling patterns and nonlinear parallel imaging reconstruction

F. Knoll[1], C. Clason[2], F. Ebner[3], M. Aschauer[3], R. Stollberger[1]

[1]Institute of Medical Engineering, TU Graz, Graz, Austria

[2]Institute for Mathematics and Scientific Computing, University of Graz, Graz, Austria

[3]Department of Radiology, Medical University Graz, Graz, Austria

INTRODUCTION

Variable density 3D random sampling trajectories which were introduced in the context of compressed sensing [1] have great potential for subsampled MR angiography techniques. The goal of this work was to present a parameter-free method to construct tailored variable density sampling patterns, which can be used together with a nonlinear parallel imaging method [2, 3]. This combination allows the use of very high acceleration factors without any application of temporal view sharing.

METHODS

The proposed method to generate the variable density 3D random sampling pattern is to use the scan of the same anatomic region of a different patient or a healthy volunteer as a template. The power density spectrum of this template can be used as a reference to generate a probability density function which is then used to construct the sampling pattern. Patterns that are generated this way can be pre-computed for different types of scans or anatomical regions. The template and the sampling patterns for R=30 and R=60 are displayed in **Fig. 1**. Image reconstruction was performed with an iteratively regularized Gauss-Newton method (IRGN) [2].

A CE-MRA dataset (3D Gradient Echo Sequence, TR/TE=3.74/1.48ms, FA=30°, matrix: 448x352x40, resolution: 0.55x0.55x0.70mm3) of the carotid arteries was acquired on a clinical 3T system and subsampled retrospectively, to simulate an accelerated acquisition. Acceleration factors of R=20, 30, 40, 50 and 60 were used. Parallel imaging with 8 receiver coils, compareable to the spatial positions of the individual elements of the receiver head coil that was used in our experiments, was simulated by use of Biot Savart's law.

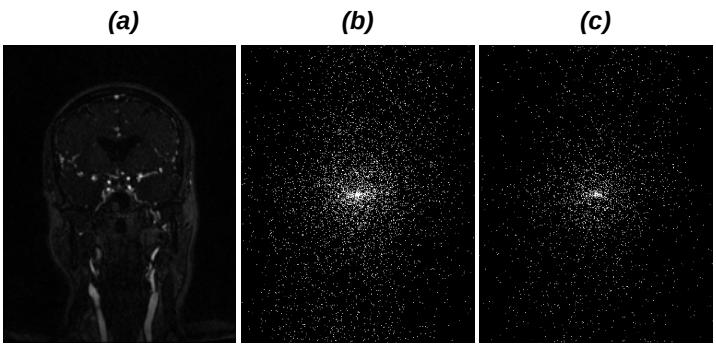

Fig. 1: *(a) Template, (b) Generated random 3D sampling pattern for R=30, (c) Generated random 3D sampling pattern for R=60.*

Acceleration	R=20	R=30	R=40	R=50	R=60
RMS Error	0.017±0.015	0.030±0.023	0.042±0.027	0.050±0.032	0.057±0.063

Table 1: *RMS Differences to fully sampled data set for all acceleration factors. Mean values and standard deviations over all 40 slices are displayed.*

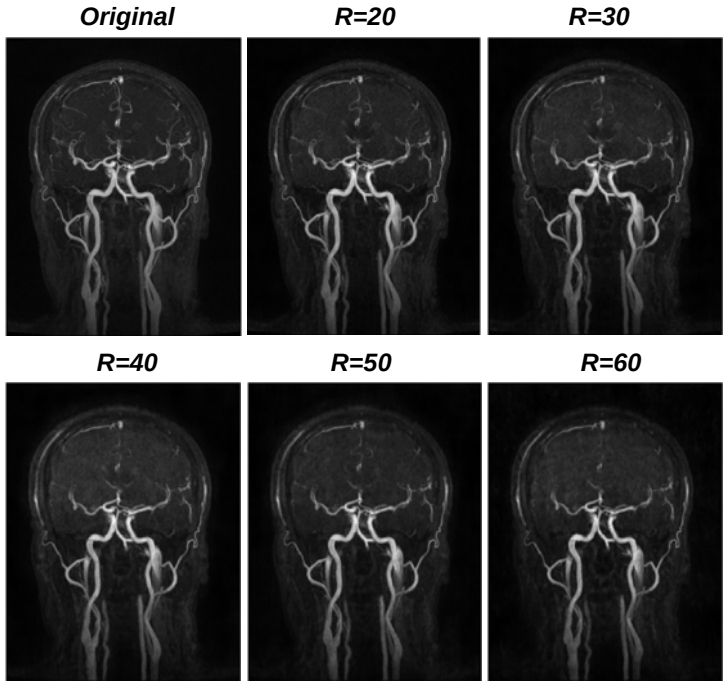

Fig. 2: *CE-MRA Dataset of the carotid arteries: Original fully sampled data set and subsampling with acceleration factors R=20,30,40,50 and 60.*

RESULTS AND DISCUSSION

Our results show that excellent image quality can be achieved even for very high acceleration factors (**Fig. 2**) without any application of temporal view sharing. For acceleration factors up to 30, only a slight decrease of SNR and a minimally reduced contrast for the smallest vessels result. If higher acceleration factors is used, it can be seen that small vessels are lost in the reconstructions. However, the SNR is still excellent considering the amount of acceleration. The RMS differences to the original fully sampled data set are displayed in **Table 1** (mean RMS and standard deviation over all 40 slices are shown).

The proposed approach ensures that the tuned ratio of low to high sampled frequencies is particularly suited to angiography scans, allowing higher acceleration factors than a fixed ratio. One major advantage is that the method is completely free of any user-defined parameters. Our experiments showed that the method is robust regarding the choice of the reference image, as the only information that has to be obtained is an estimate of the ratio of high to low frequency components. The exact anatomical details are not important in this context.

REFERENCES

[1] Lustig et al., MRM 58: 1182-1195 (2007), [2] Uecker et al., MRM 60: 674-682, [3] Knoll et al., ISMRM 2009: 2721

Acknowledgements: SFB F3209-18